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COVER: A Jersey × N'dama crossbred cow in Ivory Coast. The Jersey breed is used widely in crossbreeding for milk production in the tropics (IEMVT photo).

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DAIRY DEVELOPMENT IN THE THIRD WORLD

Dairying as an instrument of economic and social change was the main theme of the XIXth International Dairy Congress held in India in December 1974. This issue of *World Animal Review* is devoted principally to a further consideration of the problems of dairy development in the third world countries.

Recognizing that increased milk production can play an important role in the economy of small farmers, the opportunities for developing dairying are discussed under conditions where cheap sources of roughage are available, where intensification of arable farming is possible and market outlets for farm animals and their produce exist. The role of crossbreeding in raising dairy productivity is considered in the context of over 20 years of research and practical experience in Sri Lanka and Jamaica. The results of a study of various measures and techniques adopted to increase milk production in rural areas and strengthen the small and marginal farmers and agricultural labourers in south India are presented. The economic problems that have been frustrating the progress of milk schemes in the developing countries that might be more effectively tackled in the future by new initiatives in policy and management are examined. The remaining articles in this issue of *World Animal Review* are concerned with the minimum levels of concentrate feeding for efficient milk production, the possible use of waste cellulose as an energy source for animal protein production, and new trends in ensiling forages.

A number of important conclusions are drawn that are relevant to dairy development. In many dryland situations milk should continue to be produced as a by-product to crop farming, employing traditional systems of husbandry; however, substantial increases in output may be achieved through improved feeding, a small amount of supplementation with concentrates, better veterinary attention and the introduction of a wide-ranging milk collection system. More intensive forms of dairying using crossbred cows could be undertaken under conditions where year-round supplies of good quality green fodder are available; but specialized dairying would only be possible if price policies for milk are favourable.

Where it is feasible to adopt a crossbreeding programme to improve the indigenous stock by the introduction of European blood (but not to upgrade them, because of problems of climatic stress), two options are possible — either new breed formation or the adoption of a crisscrossing or rotational crossbreeding system. Where new breed formation is desired, it is important to ensure that the foundation stock used is an improved zebu, that there is participation of a large number of milk-recorded herds and that they are all fully involved in sire testing. Under a rotational crossbreeding system, the whole of the national herd in a given area could become involved and participate in the programme even in the absence of a milk-recording system. The role of the government livestock stations would then be to serve as nucleus herds providing superior sires, rather than as centres for the multiplication of breeding stock for distribution to farmers.

Measures to improve the lot of the socially and economically weaker sections of the rural population through dairying should be pursued with greater vigour and determination than hitherto. The small numbers of crossbred dairy cows owned by the poor landless cultivators and small farmers in the study of dairy development in south India are a reflection of (*i*) the inadequacy of the strategy of artificial insemination for improving the productivity of their stock, (*ii*) their inability to raise the substantial capital required for the purchase of crossbred cows, and (*iii*) the higher costs and risks involved in the raising of crossbred animals. Greater support to the development of other classes of stock as milch animals may therefore be warranted in these circumstances. Furthermore, programmes for promoting milk production in the rural areas should be accompanied by reforms that would improve the economic status of the rural poor if increased social polarization is to be avoided.

One of the most serious obstacles to dairy development arises from the ineffective way in which many public sector milk schemes are formed and operated. It is now abundantly clear that where these are organized through cooperatives there should be the constant involvement of and support from the smallholder producer; otherwise they are headed for serious problems. It is heartening to note the sustained progress of two cooperative milk schemes in India — at Anand and Mehsana — which may yet pave the way for a more widespread adoption of true cooperatives that combine public responsibility with commercial efficiency.

THE EDITOR

THE PLACE OF LIVESTOCK IN SMALL FARM DEVELOPMENT

by H.H. Groenewold and P.R. Crossing

Livestock are an important factor in the economy of small farmers. In addition to food, they provide fuel, raw material for clothing and shelter, and draught power and manure for the cultivation of crops. The sale of animals or their produce often provides the only cash income received by small farmers.

In India, about 60 percent of all stock feed available is derived from arable agriculture; 40 percent stems from the natural vegetation growing on wastelands and fallows. Ruminant husbandry is fully integrated into the existing land-use systems. In many situations, small farmers can only keep the livestock needed for traction. In others, where cheap sources of roughage are available on public land in the vicinity, where intensification of arable farming is possible and market outlets for farm animals and their produce exist, the raising of livestock in addition to the animals required for farm traction can be a profitable activity for a small farm. An example of the role cattle can play in these situations is set out in this article, which is concerned with the production aspects of small farm development.

Much of any increase in production on small farms will be retained for home consumption, but some surplus will also become available for sale. Attention to market outlets is therefore of great importance. In India, much study is being given to the establishment of sales outlets for fresh milk in rural areas.

Both authors are staff members of the FAO/World Bank Cooperative Programme. This study is a summary of work undertaken during the preparation and appraisal of a Drought Prone Areas Project in India, now being implemented. The views expressed are those of the authors, and do not necessarily reflect the views of the FAO/World Bank Cooperative Programme.

The small farms

In the drought-prone areas of India, rainfall averages about 400 mm a year and falls in heavy downpours. Soils are variable but many are suitable for arable farming. In the regions for which this study is made, the average size of farms without irrigation is about 4 hectares, and farmers mainly grow *bajra* (pearl millet) or *jowar* (sorghum), using a pair of bullocks — one owned, one borrowed from a neighbour — to pull a chisel plough for land cultivation. Many farmers also keep a cow to breed bullock replacements, and provide milk for home use or sale in the form of ghee. All animals are fed on crop residues and grazed on stubble and grasses available on areas of range (wasteland) near the owners' holdings.

It is estimated that on such holdings an average 3.7 hectares are cultivated each year — jowar/bajra 3 hectares, pulses/oilseeds 0.7 hectare. Crop yields are low and variable, and no inputs are used other than the seed retained from the previous crop. Roughage supplies from a 4-hectare farm and 3 hectares of wasteland amount to 8.3 tons — sufficient for a cow plus followers and the bullock. Livestock yields are also low: the calving percentage is about 60 percent, mortality about 15 percent and milk yield per lactation about 300 litres. All of this results in a farm income of Rs.1 650 (US$220) for a family of about six people. Family labour available per farm is about 600 man-days per year (three adults × 200 days) and currently about 330 days are used on crops and 34 days on the cattle; 236 days remain unused.

Two possibilities exist for developing such farms: one is to increase the output from dryland farming and the

an Indian example

ALL PHOTOS: GROENEWOLD

Above: Native cow, kept primarily for breeding draught bullocks, with her crossbred daughter. Crossbreeding with European cattle was initiated some 70 years ago in India, and the superiority of the crossbred for dairying, with adequate feeding and management, is now well accepted.

Left: Draught animals in India perform about 90 percent of seedbed preparation, and do nearly all the hauling of materials to fields and local markets.

Below: Although the number of diesel and electric pumps in India increased from some 200 000 in 1965 to 2.7 million by 1972, oxen are still important for drawing well water for irrigation. One pair of bullocks is generally capable of lifting enough water to irrigate half a hectare.

other is to develop groundwater for well irrigation. Different systems of improved cattle production could be incorporated in both situations, except that crossbred cattle cannot be kept on farms without irrigation due to the poor quality of roughage supplies.

Dryland development

Dryland output could be improved by bunding to reduce rainfall runoff; the use of improved seeds, fertilizers and pesticides; supplying concentrate feeds; and providing vaccines and other veterinary needs for the farm cattle. These simple improvements in management techniques would in-

crease average farm income by about 100 percent (Table 1). Livestock income increases because of higher milk output from the concentrate feeding, reduced mortalities as a result of disease control measures, and because more roughage supplies become available when crop growing techniques are improved — a 20 percent increase in roughages in this example. These simple low-cost changes in livestock management techniques bring high returns with native breeds in dryland farming.

Table 1 **DRYLAND DEVELOPMENT — INCOME EFFECTS**

	Net farm income		
	From crops	From cattle	Total
		rupees [1]	
Current income	1 350	300	1 650
Improved income (with bunding, seed, pesticides, fertilizer, concentrate feeds, medicines)	2 300	800	3 100
Internal rate of return = 100 percent			

[1] U.S. dollar equals 7.5 rupees.

Irrigation development

A well, producing about 12 000 cubic metres a year, with a sufficient flow during the months of peak requirement to satisfy crop needs, could be developed on many farms. With irrigation development it becomes possible to introduce a much wider range of crop and livestock systems on the farm, but the role of livestock is far from clear. To find the most profitable farming system in these situations, a linear programming model of a farm was constructed. This model included all the options open to a typical farmer, both crop and livestock. The four livestock options ranged from the current traditional system to a system based on crossbred cows and improved feeding (Table 2). Each has different feed, labour and capital needs. The main prices included in the analyses were: concentrates, Rs.1.2/kg; cost of production of lucerne, Rs.0.08/kg; farm-produced roughage, no cost; selling price of milk, Rs.1.2/litre.

A computer made all the calculations and produced the details of the most profitable form of organization for a 4-hectare farm. This programme is one based on intensive cropping, with livestock playing a supplementary role (Table 3).

Dryland crops would be grown on about 1.8 hectares of the farm and 0.3 hectare would be fallow. About 1.9 hectares would be developed for irrigation. In the summer, 1.8 hectares would be cropped to improved varieties of bajra or jowar and 0.1 hectare to intensively produced high-yielding lucerne. In the winter, 1.2 hectares would be devoted to irrigated wheat and 0.1 hectare to lucerne. All lucerne production would be cut and hand-fed to crossbred dairy cows, which would be managed to produce 1 800 litres/lactation from farm-produced feeds. These cows would replace the indigenous cows kept under traditional husbandry. This system, using crossbreds, is su-

Table 2 **LIVESTOCK OPTIONS — KEY DATA**

		Systems using indigenous cows			System using crossbred cows
		Traditional	Improved	Best	Best
Yields					
Milk	*litres/lactation*	300	600	1 200	1 800
Calving	*number dropped/cows mated - percent*	60	75	75	75
Weaning	*number weaned/cows mated - percent*	48	69	69	69
Adult mortality	*percent*	10	4	4	4
Feed consumption					
Roughage	*tons/cow unit*	5.5	5.4	5.8	6.0
Concentrate equivalent [1]	*tons/cow unit*	—	0.3	0.5	0.8
Labour required	*man-days/cow unit*	34	52	80	90
Capital required	*rupees/cow unit*	700	1 000	1 500	2 200
Gross margins (excluding feed costs)	*rupees/cow unit*	300	800	1 600	2 200

[1] Also includes fresh lucerne expressed in terms of its concentrate feed value.

Table 3 **BEST FARM PROGRAMME — WITH IRRIGATION**

Crops	*hectares*
Dryland rotation	1.8
Irrigated bajra/jowar - summer	1.8
Irrigated wheat - winter	1.2
Irrigated lucerne - year-round	0.1
Fallow	0.3
Maximum irrigated area/season	1.9
Labour	*man-days*
Family	543
Hired summer	145
Increased labour use	358
Livestock	*number*
Crossbred cows and followers	1.7
Draught bullock	1
Net income per year	*rupees*
Total per year	7 700
Increase	6 050
Additional capital required	*rupees*
Irrigation	11 100
Livestock	3 800
Total	14 900
Internal rate of return = 35-40 percent	

Table 4 **SUMMARY OF DEVELOPMENT ALTERNATIVES**

		Current situation	Best dryland	Limited irrigation	Full irrigation	
					Best solution [1] (A)	(B)
Total irrigation water used	*cubic metres*	—	—	4 000	12 000	12 000
Indigenous cows	*number*	1	1.2	—	—	—
Crossbred cows	*number*	—	—	1	1.7	1.8
Net farm income	*rupees*	1 650	3 100	3 900	7 700	7 400

[1] Protein for lactating cows supplied by (A) lucerne, (B) purchased concentrate feeds.

perior to the system of using irrigated fodder for indigenous cows producing 1 200 litres/lactation. The increased activity on the farm would require an additional 358 man-days of farm labour each year; of this, 145 man-days in the summer season would have to be hired. Rs.14 900 would be required to develop a farm to the above level.

Annual net income would increase substantially over the current position: Rs.7 700 compared with Rs. 1 650. Of the Rs.6 050 increase, Rs.2 200 would be contributed by cattle. If it takes five years to reach full development, the financial rate of return before debt service would be 35-40 percent.

This "best farm" was tested to see how sensitive it was to price changes: (*a*) milk, a 25 percent increase from Rs.1.2/litre to Rs.1.5/litre, and (*b*) fertilizer (× 2), irrigation water (× 3) and capital charges (× 3). It was found that the best farm programme did not change with these price changes; the only change was in the level of income obtained from it. Livestock numbers did not increase when milk prices rose, owing to lack of cheap roughage to supply the main part of the animal diets. It did not pay to grow extra roughage on the farm, and the purchase of roughage from other farms is only possible in small quantities.

Sources of protein

Lucerne, which is the main source of protein in the best farm programme, cannot be grown in all areas owing to soil and pest problems. Purchased concentrate feeds then become the cheapest source of protein for lactating cows, and the water not needed for lucerne is then best used to grow irrigated grain crops, not high-yielding grasses. This all leads to slightly increased supplies of coarse roughage on the farm, so that in the best farm programme without lucerne 1.85 cows can be kept, compared with 1.7 cows in the best farm programme with lucerne. Net farm income is lower by about Rs.300 with this programme on account of larger concentrate purchases. This indicates that, at current prices, milk production based on purchased concentrate feeds and farm-produced roughage is slightly less profitable than milk production based on farm-produced feeds only.

Some 60 percent of milk production in India is estimated to be the by-product of breeding draught cattle. Feed supplies are almost entirely cereal straw and other crop by-products. Lactation yields are about 500 litres over 200 days every two years, but many cows, like the one pictured here, yield about 800 litres per lactation.

A special set of calculations was made for conditions which occur in a small part of the drought-prone areas. In these calculations it was assumed that, with special management and skill, lactation yields from crossbred cows would increase to 2 500 litres; that farm-gate prices of milk would be Rs.2/litre due to favourable marketing conditions; that lucerne could not be grown due to soil and pest problems; and that both roughage and concentrate could be purchased, roughage at Rs.375/ton and concentrates at Rs.1 000/ton.

Best programme

The best farm programme for this set of conditions uses almost all the available irrigation water to grow 0.75 hectare of high-yielding grasses; and it pays to run as many cows as purchased roughage and concentrates, management ability and available capital will permit. However, if milk prices are only Rs.1.5/litre then it pays to limit cow numbers on such a farm to the level that can be sustained by farm-produced roughage. Therefore, only where milk prices are about Rs.2/litre, concentrate prices Rs.1/kg, production costs of lucerne Rs.0.08/kg and milk yields about 2 500 litres can dairy farming compete with crop growing as the most profitable use of irrigation water.

Not all the typical 4-hectare farms could be expected to find a supply of 12 000 cubic metres of irrigation water with an adequate rate of flow for a growing season. Some would have only about 4 000 cubic metres available. Their best farm programme would be similar to that for the farm with 12 000 cubic metres, except that the areas of bajra, wheat and lucerne would be smaller. There would be one crossbred cow instead of a native cow, and the net farm income would be Rs.3 900.

Conclusions

In developing small farms in the drought-prone areas of India, substantial rises in farmer income could be achieved through increased levels of crop and livestock technology combined with on-farm capital investments. In the dryland situation, farm income from a 4-hectare farm could increase from Rs.1 650 to Rs.3 100; i.e., an increase of some Rs.1 500 of which about 30 percent comes from cattle. Where it is possible to develop irrigation, farm income could increase from Rs.1 650 up to Rs.7 700. This would be achieved by developing irrigation facilities to the limits of available water. The range of net farm incomes between the current situation, dryland development and irrigation development is large, but in all, at current prices, livestock play a supplementary role to crop production (Table 4).

In using these results for development planning, consideration needs to be given to the returns to capital measured by the internal rate of return. Internal rates of return from dryland development (100 percent and over) are higher than those for irrigation development (35-40 percent). This would mean that where capital is limited its best use would be for large areas of dryland development rather than for small areas of irrigation.

Dairy farm development

Implications for dairy development planning in India are that at current prices milk should continue to be produced as a by-product to crop farming. However, substantial increases in output could be achieved on dryland farms from well-fed indigenous dairy cattle and buffaloes, maintained under traditional systems of husbandry and supplied with small quantities of concentrates and better veterinary attention. Expanding dairying in this way would raise the incomes of small farmers in rural areas and would require wide-ranging milk collection systems. More intensive forms of dairying could be undertaken on irrigated lands where crossbred cows could be introduced to make use of the year-round supplies of good quality green fodder. Farmers participating in such schemes would not usually be found among the rural poor. With present prices in most farming areas, specialized dairying is not as profitable as crop growing with milk production as a by-product, so, if specialized dairy farms are to be encouraged, policies resulting in substantially higher milk prices would have to be adopted.

Crossbreeding for milk production in Sri Lanka

by V. Buvanendran and P. Mahadevan

The indigenous cattle of Sri Lanka, the Sinhala, in common with most other cattle of the tropics, are poor dairy animals. They are small, with an average adult weight of 160 kg. Their mean 305-day lactation milk yields are around 450 kg. This level of production, while it may satisfy the needs of subsistence farming, is too low for commercial dairying. It is therefore necessary to improve the production potential of the cattle in order to make them profitable.

The climatic conditions under which cattle are raised in Sri Lanka vary widely. The agroclimatic zones may be broadly classified into: dry zone, coconut triangle, midcountry and hill country. The ecology of these areas is shown in Table 1. About two thirds of the cattle are in the dry zone, 25 percent in the coconut triangle, and the remaining 8 to 10 percent in the midcountry and hill country areas where dairy managerial skills are well developed and high levels of concentrate feeding are adopted under systems of intensive husbandry. The coconut triangle, although hot and humid, is also regarded as an area of high dairy potential, partly because dairy farming has been a traditional enterprise of the farmers in this zone and partly because of the success in cultivating pasture grasses such as *Brachiaria miliformis* and *Brachiaria brizantha* as inter-crops. The coconut palms also provide a certain amount of shade and offer some measure of protection from solar radiation. In the dry zone the cattle forage on poor natural pastures with virtually no inputs of concentrate feed; managerial skills are limited, and milk is regarded as a by-product of animals that are raised mainly for beef.

Sinhala heifer at Karagoda-Uyangoda

The Government has large cattle farms of European breeds — primarily the Ayrshire, Jersey and Friesian — in the hill country areas that have a high dairy potential. The success that has been achieved during the last two to three decades with purebred herds of these breeds and with the upgrading of local cattle shows that high levels of European blood are not inimical to high milk production in this zone. The well-known "Hatton" or "Cape" cattle found in the hill country are believed to be descendants of European cattle brought to Sri Lanka by the early Dutch settlers some 300 years ago. They acquired a certain amount of indigenous blood by crossing with the local cattle and were developed without any proper breeding policy or plan. The dairy merit of these animals lends support to the present

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policy of upgrading all the indigenous cattle in the hill country to European breeds.

In the coconut triangle and the dry zone, climatic conditions are unfavourable for the adoption of a straightforward upgrading programme. The dry zone has the further disadvantage of poor nutrition, because forage in terms of both quantity and quality is limited mainly to the rainy season. Crossbreeding research has therefore been directed at evolving breeding policies that would be suitable for these two zones. The present article discusses the results of research carried out over the last 20 years and their possible application to national programmes. The experiments were carried out at the government livestock stations at Karagoda-Uyangoda, Undugoda and Wirawila (see Figure 1).

FIGURE 1. AGROCLIMATIC ZONES OF SRI LANKA

NOTE: The "other areas" marked on the map have a hot, wet climate, and do not fall into the broad classification of agroclimatic zones (see also Table 1).

Karagoda-Uyangoda experiment

Karagoda-Uyangoda is located in southern Sri Lanka, at an elevation of 30 metres above sea level with a mean annual temperature of 26.7°C and a relative humidity of 78 percent. Annual rainfall averages 2 500 mm. Crossbreeding work at the government livestock station was initiated by Mahadevan (1953). The experimental design is shown diagrammatically in Figure 2. Sinhala cattle were crossed with either Jersey or Friesian sires. The F_1 generation was bred inter se to produce F_2 generations of both breed crosses. In the Jersey × Sinhala crossbreeding programme, part of the F_1 population was backcrossed to the Jersey to produce a B_1 generation with 75 percent Jersey blood. In the Friesian programme, the F_2 animals were carried through to the third filial generation by inter-se mating among the F_2. The results obtained during the periods 1956-66 (Wijeratne, 1970) and 1968-73 (Buvanendran, 1975, unpublished) are summarized separately in Table 2.

It will be observed that F_1 animals from both the Jersey × Sinhala and the Friesian × Sinhala matings showed a remarkable increase in milk yield over the indigenous Sinhala

TABLE 1. Agroclimatic zones of Sri Lanka

Zone	Elevation	Mean monthly temperatures	Rainfall	Humidity
	Metres	*Centigrade*	*Millimetres*	*Percent*
Dry zone . . .	0	23.8-32.2	890-1 900	75-90
Coconut triangle	0-457	23.8-29.4	1 900-5 080	62-80
Midcountry . .	305-914	18.3-23.8	1 900-5 080	65-75
Hill country . .	Above 914	10.0-23.8	2 160-3 175	58-75

cattle, but the F_2 animals exhibited a marked decline in yield from F_1 levels. Further interbreeding to the F_3 stage in the Friesian programme did not produce any significant change in performance from the F_2. Comparison of F_1 performance in the Jersey programme with contemporary F_2 and B_1 production levels respectively suggests that although backcrossing to the European parental breed gave relatively better results than the inter-se mating of F_1 animals, the levels of production attained in the B_1 were nevertheless considerably lower than in the F_1.

These results suggest that hybrid vigour is responsible for part of the higher yields in the F_1 and for the subsequent depression in the F_2 and B_1. The F_2 and B_1 animals lose 50 percent of the hybrid vigour present in the F_1, but the relative superiority of the B_1 animals over the F_2 may be attributed to the additional amount of Jersey blood. The data on calving intervals suggest that the additional Jersey inheritance in the B_1 did not lower reproductive potential.

Undugoda experiment

This farm is located in the mid-country zone at 180 metres above sea level. The average annual rainfall is 2 500 mm. Mean monthly temperatures vary from 23.0 to 31.1°C and mean relative humidity is 71 percent. The cattle are housed in sheds and zero grazed on *Brachiaria brizantha* pastures. Red Sindhi cows were mated to Jersey sires to produce F_1 animals. F_2, B_1 and 5/8 Jersey offspring were also produced by mating F_1 animals inter se, backcrossing to Jersey or mating F_1 to B_1 animals. A purebred herd of Ayrshire was maintained contemporaneously and this served to provide a control population during the major part of the experimental period.

Data on milk yield and other characteristics of economic importance are presented in Table 3 (Buvanendran, 1974).

The results are essentially similar to those of the Karagoda-Uyangoda experiment. The yields of the B_1 animals were lower than those of the F_1 but closer to the latter than to the F_2. The difference between the Karagoda-Uyangoda and Undugoda experiments is probably due to the favourable climatic and managerial conditions at Undugoda that permitted a fuller expression of the Jersey genotype in these animals. It may also be noted that the performance of the Jersey F_1 in this experiment is similar to that of the purebred Ayrshire. Reproductive performance as measured by the length of the calving interval varied with the different crosses, but there was a general tendency for calving intervals to increase with an increase in *Bos taurus* blood.

The B_1 and F_2 animals in this experiment were born and commenced lactation at about the same time, so that the treatments accorded to them were similar. The differences in performance may therefore be regarded as largely genetic.

Wirawila experiment

This government farm is located in the typical dry zone of Sri Lanka. Mean annual temperature is 27.1°C and average precipitation 1 075 mm. Breeding work at this station commenced with Sinhala animals, but these were first mated to Red Sindhi sires to produce females with varying levels of Red Sindhi blood (ranging from 1/2 to 7/8), and these were then crossed to either Shorthorn or Jersey sires.

The production characteristics of Red Sindhi × Sinhala crosses obtained during the period 1961-69, and of Shorthorn and Jersey crosses with

FIGURE 2. DESIGN OF EXPERIMENT AT KARAGODA-UYANGODA

STAGE I	Jersey ♂♂ × Sinhala ♀♀ ↓ F_1	Friesian ♂♂ × Sinhala ♀♀ ↓ F_1	Sinhala ♂♂ × Sinhala ♀♀ ↓ Sinhala
STAGE II	F_1 ♂♂ × F_1 ♀♀ ↓ F_2	F_1 ♂♂ × F_1 ♀♀ ↓ F_2	Sinhala ♂♂ × Sinhala ♀♀ ↓ Sinhala
STAGE III	Jersey ♂♂ × F_1 ♀♀ ↓ B_1	F_2 ♂♂ × F_2 ♀♀ ↓ F_3	Sinhala ♂♂ × Sinhala ♀♀ ↓ Sinhala

TABLE 2. Production characteristics of different breeds at Karagoda-Uyangoda

Breed	1956-66			1968-73		
	Milk yield	Lactation length	Calving interval	Milk yield	Lactation length	Calving interval
	Kg	.... *Days*		*Kg*	.... *Days*	
Friesian × Sinhala:						
F_1	1 573	327	393	1 482	387	442
F_2	987(34)	302(34)	448(34)	981	333	421
F_3	—	—	—	957(30)	332(30)	438(30)
Jersey × Sinhala:						
F_1	1 215	313	370	1 076	377	453
F_2	809(34)	273(34)	412(34)	—	—	—
B_1	—	—	—	948	344	407
Sinhala	570	224	391	234(24)	186(24)	467(24)

SOURCES: 1956-66 data, Wijeratne (1970); 1968-73 data, Buvanendran (1975, unpublished).
NOTE: Figures in brackets give number in mean for less than 50 observations.

TABLE 3. Production characteristics of different breeds at Undugoda, 1957-71

Breed	Milk yield	Lactation length	Calving interval	Age at first calving
	Kg	..... *Days*		*Months*
Ayrshire	1 956	341	437	32.9
Jersey × Sindhi:				
F_1	1 929	295	368	33.7
F_2	1 115(49)	265(49)	430(49)	33.0(49)
5/8	884	265	373	36.3
B_1	1 700	317	434	39.6

SOURCE: Buvanendran (1974).
NOTE: Figures in brackets give number in mean for less than 50 observations.

TABLE 4. Production characteristics of different breeds at Wirawila

Breed	1961-69			1970-73		
	Milk yield	Lactation length	Calving interval	Milk yield	Lactation length	Calving interval
	Kg	.... *Days*		*Kg*	.... *Days*	
Sindhi × Sinhala:						
F_1	770	228	423	—	—	—
B_1	760	253	439	—	—	—
Sindhi	908	247	426	882(49)	262(49)	457(49)
Jersey × grade Sindhi, F_1	—	—	—	1 209(37)	303(37)	389(37)
Shorthorn × grade Sindhi, F_1	—	—	—	1 320	287	397

SOURCE: Data collected by Buvanendran and Tilakaratne (1974, unpublished).
NOTE: Figures in brackets give number in mean for less than 50 observations.

the grade Sindhis during 1970-73, are summarized in Table 4 (Buvanendran and Tilakaratne, 1974, unpublished data). The contemporary records of Sinhala cattle are not available, because these animals had been disposed of at the time that the F_1 and higher grades had come into milk. Nevertheless, the results are indicative of the increase in yield obtainable by crossing the Sinhala with the Red Sindhi.

The yields of the F_1 are close to the expected mean of the two parental breeds (if it is assumed that the yield of the Sinhala parents at Wirawila would have been similar to that obtained at Karagoda-Uyangoda during the same period). This suggests a simple additive genetic effect on milk yields when two zebu breeds are crossed. Any heterotic effect is probably of a small order. Further upgrading to the Red Sindhi did not result in any further increase in yield. However, the introduction of European blood resulted in a marked improvement in milk production, the crossbred animals giving nearly 50 percent higher yields than the Red Sindhi. The reproductive performance of the European crosses was also superior to that of the Red Sindhi.

It is relevant to note that the performance of the Jersey crosses at Wirawila is higher than that of the Jersey crosses in the Karagoda-Uyangoda experiment during the same period, even though climatic and managerial conditions were less favourable at Wirawila. This is probably due to the superiority of the foundation zebu stock (Sindhi × Sinhala crosses) used at Wirawila. The Undugoda results also lend support to this interpretation.

General conclusions

On the basis of the results of the three experiments outlined above, the following general conclusions may be drawn:

1. Milk production from F_1 European × zebu crosses is markedly superior to that obtained from the base zebu population. Progeny from Friesian matings to the zebu produce

Jersey × Sinhala crossbred cow at Karagoda-Uyangoda

more milk than those from corresponding Jersey matings.

2. Interbreeding of the F_1 progeny results in a marked decline in milk yield, the reduction in yield at the F_2 level averaging 30-40 percent. Further interbreeding to the F_3 generation does not lead to any further significant decline. These results point to an appreciable degree of hybrid vigour in the F_1 and its loss in the F_2 and F_3 generations.

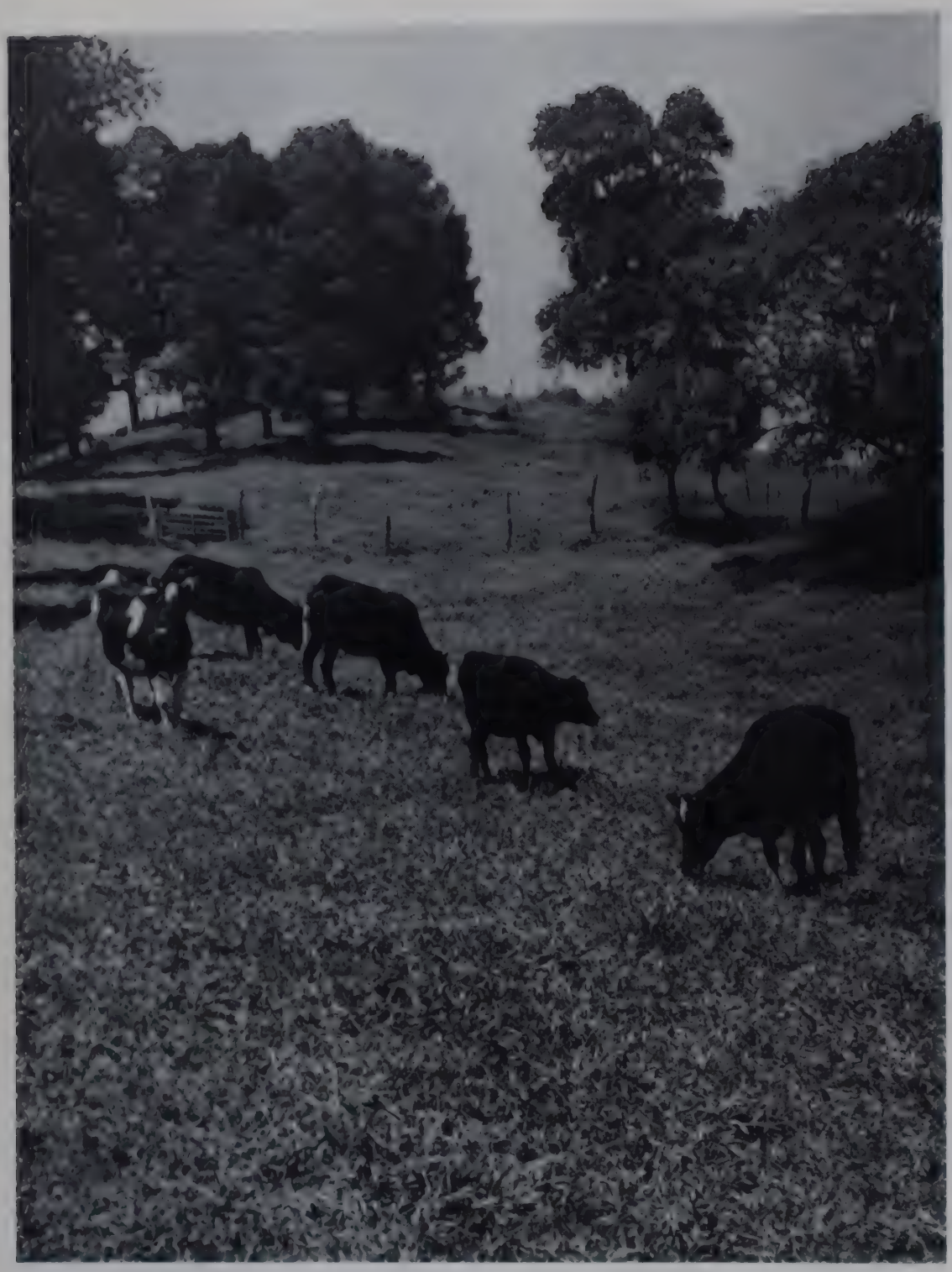
3. Backcrossing the F_1 to the European breed results in performance levels that vary considerably with climatic and managerial conditions. Under relatively mild climatic conditions and with minimal exposure to heat stress (as at Undugoda under zero grazing), B_1 animals can produce at a level fairly close to the F_1, whereas under harsher climatic conditions (as at Karagoda-Uyangoda), B_1 production would be lower than F_1, although relatively higher than F_2.

4. Inasmuch as the genetic merit of the European parent has an influence on the performance of the F_1, the genetic merit of the zebu is also important, as evidenced by the results from Undugoda and Wirawila, where purebred Sindhis or Sindhi × Sinhala crosses were used as the foundation zebu stock.

National breeding programmes

In deciding on a national breeding programme to improve the indigenous zebu stock by the introduction of European blood, two options are possible — either new breed formation or the adoption of a crisscrossing or rotational crossbreeding system. Where new breed formation is desired, it is necessary to decide early on in the programme the European breed that is to be used for crossing with the indigenous zebus, and the level of European blood that should desirably be incorporated into the new breed. Where the evidence suggests that a system of rotational crossbreeding using two or more breeds is likely to be more fruitful than new breed formation, the decision concerns the number and choice of breeds to be used in the rotation.

For new breed formation, the choice of European breed should be made with the aim of maximizing yield in the F_1, so that despite the loss of heterosis in the F_2 and B_1 generations high yields would still be possible when the level of European blood that should desirably be incorporated into the new breed has been reached and inter-se mating takes place. From the experimental results obtained in Sri Lanka, it would appear that the Friesian would be more suitable than the Jersey as the European parent for areas, such as the coconut triangle, which have a high dairy potential notwithstanding the tropical climate. Prevailing meat prices could also influence the choice of breed.



Cows on pasture at Karagoda-Uyangoda

For the dry zone, however, the Jersey has distinct advantages because of environmental and managerial considerations. It would also seem that using an improved zebu such as a grade Sahiwal or Sindhi as the foundation stock would pay dividends in the long run by ensuring higher performance in the F_1 and subsequent generations. This may be regarded as impractical on the grounds that it would delay the introduction of European blood into the programme by one generation. Nevertheless there are areas, such as the dry zone of Sri Lanka, where an immediate introduction of European blood is not feasible due to the prevailing poor standards of nutrition and management. In such areas the slower, two-stage process of improvement would be more suitable.

A similar conclusion was reached by Mahadevan *et al.* (1962) in their genetic study of the Sahiwal grading-up scheme in Kenya: they stated that the Sahiwal breed in Kenya provided a satisfactory first stage for grading up the East African zebu to a more productive level in areas of medium agricultural potential; the second stage would then consist of one or perhaps two introductions of European blood into the Sahiwal grade stock, depending on the level of management attained by the stock owners at the end of the first stage and on the general climatic conditions of the area. The decision on the level of European blood that should desirably be incorporated in any national crossbreeding programme in Sri Lanka would be governed by similar considerations.

The lessons learned from new breed development in Jamaica (Wellington and Mahadevan, in this issue), concerning the need to ensure the participation of a large number of milk-recorded herds and their full involvement in sire testing, are particularly relevant to Sri Lanka where both milk recording and sire evaluation are largely confined to government-owned herds. Jamaican experience has demonstrated that a relatively small nucleus of animals of a new breed, developed within one or perhaps a few government herds, is unlikely to make any significant impact on milk production in a time span of 20 to 25 years without the cooperative efforts of a number of participating farmers.

Rotational crossbreeding

The second option for a national breeding programme for the coconut triangle and the dry zone of Sri Lanka — crisscrossing or rotational crossbreeding, using zebu and European breeds — appears to be better according to the experimental evidence (although animals with two thirds zebu blood are likely to be unacceptable to many milk producers — see below). This conclusion is based on two principal considerations. The first is the large decline in performance from the F_1 to the F_2 generation in both the Karagoda-Uyangoda and Undugoda experiments, which indicates the presence of a high degree of hybrid vigour. The second is the relative superiority of the B_1 animals over the F_2 although the magnitude of this superiority varies with climatic and managerial conditions.

Two practical questions would need to be answered in designing and implementing a rotational crossbreeding

Top picture: Jersey × Sindhi crossbred cow (right) and purebred Sindhi cow at Wirawila. Lower picture: Sinhala bull at Karagoda-Uyangoda

programme, namely, the number of breeds that should be used in the rotation and the choice of breeds. A two-breed rotation involving a zebu and a European breed has the advantage that it is simple to operate, and when equilibrium is reached it should be possible to distinguish the cows with two thirds European and one third zebu genes from those with one third European and two thirds zebu genes; this would facilitate the choice of sires that should be used on each type of cow. Furthermore, there is no experimental evidence to suggest that three-breed combinations will offer greater advantages than two-breed systems. But there is one major disadvantage in a two-breed rotation using widely different parental strains. This arises from the fact that there would be two kinds of animals in the population at all times, and since their production levels are likely to be substantially different it may be psychologically and commercially difficult for producers to continue with a two-breed rotational crossbreeding system. It was partly in this context that a three-breed system involving one zebu and two European breeds was recommended by Mahadevan (1970).

For a two-breed system, the breeds most suitable for the coconut triangle of Sri Lanka would be the Friesian and the Sinhala, with the proviso that if the Sinhala could be upgraded to an improved zebu before being incorporated in the rotational crossbreeding programme substantially higher yields are likely in the long run. Under dry zone conditions, the choice of the Jersey as the European breed component of the rotation has much to commend it because of the harsher environmental conditions. For the three-breed system, an improved zebu such as the Sahiwal × Sinhala or Sindhi × Sinhala cross may be used, together with the Friesian and the Jersey.

Whatever rotational crossbreeding programme is finally adopted, it would have the advantage that the whole of the national herd in a given zone could become involved in the programme even in the absence of a milk recording system. The role of the government livestock stations would then be to raise nucleus herds providing superior sires of the chosen breeds for crossing, rather than serve as centres for the multiplication of breeding stock for distribution to farmers. The importation of improved sires or their semen from other countries would serve the purpose of maintaining the quality of the nucleus herds and increasing their contribution to the national breeding programme.

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DAIRY DEVELOPMENT IN SOUTH INDIA

The introduction of modern dairy farming in India has received increasing attention and funds during the last 10 to 12 years. Many observers consider that modern dairy farming will not only provide more milk for the urban population but that it might also be an agent for social and economic change in village life. This possibility was elaborated on during the XIXth International Dairy Congress held recently in New Delhi, which had as its main theme "Dairying as an instrument of change." International and national aid agencies have been giving increasing support to the new dairy programmes. The large "Operation Flood" scheme, mainly financed by supplies of milk powder and butter oil from the World Food Programme, has been engaged for a number of years in establishing milk shed areas and processing facilities for the supply of milk to the metropolitan cities of India. Recently, the World Bank has been involved in financing a large-scale comprehensive dairy project in different localities in the country.

Crossbreeding is unlikely to transform the bulk of the indigenous cows of India into high-yielding dairy cattle; it is much more likely that the two stocks will exist side by side.

India is facing the problem of poverty among a growing number of small farmers and landless labourers, who in many areas have not been affected in any positive way by the new agricultural strategy, once optimistically called the "green revolution." New hopes have been placed on a "white revolution," and the most advanced breeding techniques are being used in the new dairy programmes. However, very little is known about the social and economic impact of these programmes. The techniques they employ, and the institutional framework for their introduction, are the critical variables. This article provides some material on these aspects at the farmer level.

The study of dairy development

In order to examine the social and economic consequences of dairy development, and in particular to study the possibilities for improving their economy that participation would give to the small farmers, the Institute for Development Research (Copenhagen) undertook a research proj-

The authors work with the Institute for Development Research, 104 Vester Voldgade, DK-1552 Copenhagen V, Denmark. This article is based on a research project carried out for the Institute by the authors. More detailed research findings are published in the Report on livestock (dairy) development in the Bangalore Milk Shed Area, Copenhagen, Institute for Development Research, 1975. IDR Papers A 75.1.

by
Klaus Nyholm,
Henrik Schaumburg-Müller
and
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Milk may be sold direct to a cooperative or a private buyer; substantial quantities are, however, marketed through a combination of the private and the cooperative marketing systems.

ect in south India in the milk shed area of Bangalore city, Karnataka (formerly Mysore) State.

The study is based on field work undertaken in the area from October 1971 to December 1973. The bulk of the data was collected from interviews with farmers in 17 villages. Two main surveys were conducted, one with 315 households selected at random, and the other with all the households (330) in the 17 villages owning crossbred animals.

Since the third five-year plan (1961-1965), it has been stated in the All-India and Karnataka plans that dairy development programmes are guided by the following objectives: (1) increasing milk production in the rural areas; (2) improvement of the nutritional standard of the population, especially among the vulnerable groups; and (3) strengthening the economy of the small and marginal farmers and agricultural labourers. The precise aim of the research project was to examine the extent to which these objectives had been met, or were likely to be met. This article deals mainly with dairy development in relation to objectives (1) and (3) mentioned above; the relation to the nutritional objective (2) has been dealt with elsewhere (Korn, 1974).

The milk shed area

Administratively, the Bangalore milk shed area is defined as the area within a radius of 40 miles from Bangalore city, and the official dairy development programmes are concentrated in the rural part of this area.

The area is dominated by dry crop cultivation, *ragi* — a millet — being the main crop on dry land. About one fifth of the net sown area is irrigated, primarily from small tanks and wells. The main crops on wet land are paddy, a subsistence crop, and vegetables for the urban market in Bangalore. The rainfall for feeding the irrigation sources is scarce (750-800 mm), and even on wet land normally only one crop is harvested per year.

The land-holding pattern in the area is characterized by many small holdings, and their number is rapidly increasing. According to the agricultural census of 1971 the total number of holdings in Bangalore district (the main part of the milk shed area) is 241 000, of which 171 000 (71 percent) occupy less than 5 acres (2 hectares)[1] of land. Together, the latter occupy 35 percent of the arable land.

[1] 1 acre = 0.4047 hectare.

The buffalo is the traditional milk animal. Bullocks of indigenous cattle breeds are used as draught animals, and the main function of the large number of local cows is the production of bullocks. In addition, the local cows give some milk, provide a little manure and are often used as draught animals. The number of bullocks in the area is rather low in respect of the amount of land that has to be cultivated. Draught power for cultivation is a scarce resource in the agricultural operations of the milk shed area.

Traditionally, milk was produced close to where it was consumed, as it was difficult to transport unless converted into ghee or *khoa* (an unfermented desiccated product in semisolid form). This meant that the milk supply for the urban areas had by and large to be produced in the cities proper or in their suburbs. The dairy development policy in India reflected this situation until relatively recently. In the centre of Bangalore city there are still a large number of herds of highly productive dairy cattle.

The total amount of milk produced in the milk shed area and in Bangalore city in 1972 was approximately 390 000 litres per day. Table 1 provides details of the sources of production. The daily average consumption of milk in Bangalore city is about 275 000 litres, of which 33 percent is produced in the city itself, 50 percent comes from the milk shed area, and the rest (17 percent) is brought in from outside. The modern Bangalore Dairy, inaugurated in 1962 and supported by UNICEF, has during the past ten years been able to harness less than 15 percent of the urban milk supply.

As may be seen from Table 1, in both the city and the milk shed area the crossbred cows are a main source of milk production. The introduction of crossbred cattle into the area goes back to the period of the first world war when the state government actively supported the breeding of local cows to Holstein-Friesian bulls in the cities. The present large dairy herds in Bangalore city are a result of this policy. During the last two decades the number of local cows and buffaloes has shown little change; increased milk production in the area has come mainly from a growing number of crossbred cows and, according to current trends, crossbreds will continue to be the main source of supply for meeting the increasing demand.

TABLE 1. Estimated milk production in the Bangalore area, 1972

	Daily average
	Litres
In Bangalore city:	
from crossbred cows . .	79 500
local cows	2 100
buffaloes	5 600
Total for the city	87 200
In Bangalore milk shed area:	
from crossbred cows . .	75 000
local cows	121 800
buffaloes	106 200
Total for milk shed area .	303 000
Total for Bangalore area	390 200

During the second, third and fourth five-year plans (1956-73) for the State of Karnataka, the resources devoted to livestock and dairy development comprised approximately 6 percent of the total development funds allocated to the agricultural sector. For the fifth five-year plan (1974-79) it is proposed to increase this share to 10 percent, or a total of Rs.170 million.

Dairy development programmes

The dairy development programmes in the milk shed area of Bangalore can be divided into three broad categories. The first deals with measures to raise milk production at the farm level. This is to be achieved principally through an increase in the number of crossbred cows, particularly through artificial insemination of local cows with semen from exotic (European) breeds. There are over 100 artificial insemination units that are intended to cover 637 villages, approximately 15 percent of the villages in the area. In addition, veterinary and other extension services, such as the distribution of fodder seeds and concentrates, are offered to the primary producer.

The second category is concerned

TABLE 2. Distribution of households in socioeconomic groups, and distribution of land, cattle and buffaloes

Socioeconomic groups	No. of households	Cultivated area (standard acres)[1]	No. of local cattle	No. of buffaloes	No. of crossbred cattle	No. of households with crossbred cattle
Rich non-cultivators	17	0	1	2	10	3
Poor non-cultivators	44	0	24	0	8	4
Small-scale farmers: (0.1-3.0 standard acres)	65	108	116	14	8	7
Medium-scale farmers: (3.1-14.0 standard acres)	135	954	367	142	48	26
Large-scale farmers: (above 14 standard acres) . . .	54	1 904	303	137	125	35
Total	315	2 966	811	295	199	75

[1] 1 dry acre equals 1 standard acre; 1 wet acre equals 3.5 standard acres.

with the marketing and processing of milk. The intention is to establish a modern marketing system that will bypass the traditional private middlemen. Through its price and credit policy and the provision of extension services, the government encourages the establishment of village-based milk producers' cooperatives for purchasing milk. The government has also established milk-collecting routes and chilling centres in the area, and built a modern dairy plant with a daily capacity of 150 000 litres in Bangalore city.

The third category involves credit for the purchase of crossbred milk cows. Loans from commercial and cooperative banks are administered through the cooperatives and are given against security in land. In the spring of 1972 the Small Farmers' Development Agency started subsidizing loans to small farmers.

Distribution of livestock

Table 2 shows the distribution of the 315 households included in the present survey, and the distribution of land, local cattle, buffaloes and crossbred animals among the five socioeconomic groups identified. Division into these groups was based on the economic resources of the households, land being the most important. It will be noted that the crossbred animals were more unevenly distributed among the farmers than the local cows and buffaloes. The large-scale farmers in the sample (here defined as households cultivating more than 14 acres) owned 63 percent of the crossbred animals but only 37 percent of local cattle and 46 percent of the buffaloes. By contrast, the poor non-cultivators and small-scale farmers owned between them 8 percent of the crossbred cattle, 17 percent of the local cattle and 5 percent of the buffaloes. The corresponding figures for the medium-scale farmers included in the survey were 24, 45 and 48 percent, respectively. It is therefore evident that for milk production the large-scale farmers tended to rely more on crossbred animals, the medium-scale farmers on the buffalo and the poor non-cultivators and small farmers on local cattle.

Since artificial insemination is offered free of charge in the area covered by this survey, one would have expected many small farmers to make use of this service for the production of high-yielding crossbred progeny. But the farmers were, in fact, hesitant to have their local cows artificially inseminated. For almost all of them dairy husbandry is of secondary importance; they are first and foremost occupied with the cultivation of their land and consequently they are concerned with their need for draught power. The suitability of crossbred male cattle as draught animals is therefore important. Opinions differ on this question, although there seems to be general agreement that the crossbred animals are as strong as the local bullocks; however, they work more slowly, do not stand the heat as well and are more expensive to feed than the local bullocks. In any event, the farmers interviewed did not consider the crossbred male cattle well suited as draught animals, and no one in the sample was using them for draught purposes.

Furthermore, the process of acquiring a crossbred cow by the artificial insemination of a local cow represents a long time lag for the farmer. It takes about four years from the time of insemination to the time the crossbred progeny will produce milk. During these four years the farmer has to spend more money on feeding the crossbreds than he would on feeding local calves. There is also the uncertainty as to whether the offspring resulting from the insemination of a local cow will be male or female; if it is a male, the farmer will dispose of it at a nominal price.

The hesitation on the part of the farmer to have his local cows artificially inseminated does not mean, however, that the insemination units are not utilized. Although few local cows are taken to the units, the crossbred cows are almost always artificially inseminated. These units, which are the most important tools in the present strategy for dairy development, are only important in multiplying the existing crossbred stock, and not in producing more milch animals through crossing with the local cattle. It was found that in 80 percent of the cases studied the first crossbred in a household was acquired through purchase. Table 3 shows how the 846 crossbred animals in the 17 villages in the survey were acquired; only 8 percent were obtained through artificial insemination of local cows.

A crossbred cow costs between Rs.1 000 and Rs.2 000, and is therefore a considerable investment for the farmers. The commercial and cooperative banks grant loans for the purchase of crossbred animals. In the present sample, however, only 40 percent of the purchased crossbred animals were acquired with bank loans. Of these loans, 58 percent had been granted to large-scale farmers, 33 percent to medium-scale farmers, and 9 percent to small-scale farmers and landless labourers. As there is no adequate insurance scheme for crossbred animals the banks give loans only against security in land, which means that the big farmers are in a much more favourable position to get institutional loans.

Milk yields and the feeding of crossbred cattle

It will be seen from Table 4 that the crossbred cows belonging to the big farmers gave higher milk yields than those belonging to the smaller farmers. It should also be noted in this connection that at the time of the interviews only a quarter of the crossbred cows belonging to the small farmers and landless labourers were yielding any milk at all, whereas more than half of the medium- and large-scale farmers' cows were in milk. Furthermore, the average yield of the cows in milk varied considerably among the different socioeconomic groups. Cows belonging to the small farmers gave 2.4 litres per day, those of the medium farmers 3.2 litres, and those of the rich non-cultivators and large farmers 4.2 and 5.4 litres respectively. These yields are based on only one observa-

TABLE 3. Mode of acquisition of crossbred animals

	Percent
Purchase with institutional loan	18
Purchase with own funds or private loan	26
Artificial insemination of local cows	8
Artificial insemination of crossbred cows	31
Natural service by crossbred bull	13
Other [1]	4
Total	100
Total number of crossbred animals	846

[1] Received as gift, or on "vara" (share-cropping) basis.

tion for each group of cows; nevertheless, the differences between groups is sufficiently large to illustrate their order of magnitude. It is equally important to note that the overall yield figures were astonishingly low in comparison with those encountered in the literature for selected herds and those normally expected by administrators and experts. Calculations based on a smaller sample, and taking seasonal variations into account, gave an average milk yield per cow of 950 litres per year, which is a far cry from the 1 650 litres used by planners in computing yearly average yields for crossbred cows under field conditions in the milk shed area (Government of Mysore, 1973).

The variations in yield were no doubt primarily due to differences in feeding pattern. The traditional livestock fodder is rice and ragi straw. Most of the local cows and buffaloes receive no other feed, except what they can eke out of grazing on scrubland. Despite the extension workers' repeated recommendations to grow fodder grass on part of the irrigated land, hardly any of the farmers set aside land for green fodder crops. Although many of the farmers in this survey were acquainted with fodder grasses, they preferred to use their valuable irrigated land for paddy, mainly for home consumption, or easily marketable crops such as sugarcane or vegetables.

Since the farmers do not grow green fodder, the use of concentrates for feeding becomes very important, especially for the crossbreds, and it is particularly in the use of concentrates that there was great variation among the socioeconomic groups. The survey showed that concentrates were used much more by bigger farmers, and as concentrates are fairly expensive this was not surprising. Most of the small farmers and landless labourers operated at a subsistence level, and few had access to any kind of working capital.

It should be noted in this context that the dominance of concentrates in any feeding pattern makes milk production very vulnerable to changes in the relative prices of milk and concentrates, with the latter being related to world market rates.

In discussing the variation in milk yield among the different socioeconomic groups, consideration must also be given to possible differences in the quality of the cows, since the term crossbred cows covers a broad spectrum of animals. Although it was not possible to trace the breeding history of every cow in the survey, it was found from case studies that the amount of exotic blood varied to a great extent (from 12.5 to 93.5 percent). It was also noted that the small farmer often owned very small crossbred animals with poor udders and with a body conformation resembling the local cattle. A comparison of the average prices paid for crossbred cows (Table 5) also suggested quality differences among the cows belonging to the different socioeconomic groups.

TABLE 4. Census of households with crossbred cattle

Socioeconomic group	No. of households with crossbreds [1]	Cows in milk	Dry/not calved	Average herd size (cows only)	Daily yield per cow in milk	Daily yield per cow
					Litres	
Rich non-cultivators	9 (7.2%)	5	4	1.0	4.2	2.3
Poor non-cultivators and small farmers	65 (8.2%)	13	41	0.8	2.4	0.6
Medium-scale farmers	130 (13.5%)	82	73	1.2	3.2	1.7
Large-scale farmers	134 (36%)	135	115	1.9	5.4	2.9
Totals and averages	338 (15.1%)	235	233	1.4	4.4	2.2

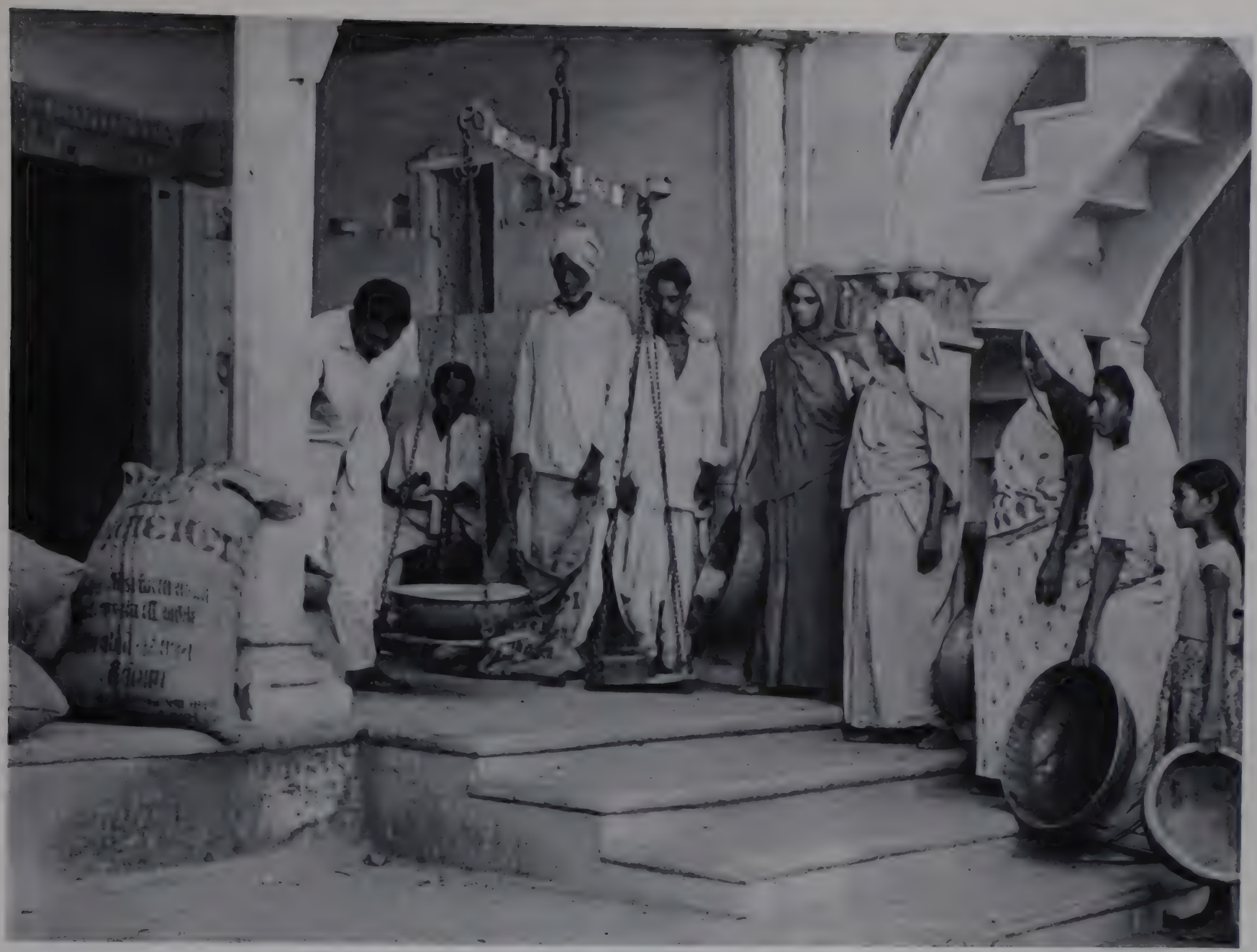
[1] The percentages in brackets relate to number of households with crossbreds in relation to the total number of households in all 17 villages.

TABLE 5. Prices of crossbred cows

Socioeconomic group	No. of crossbred cows purchased	Average price
		Rupees
Rich non-cultivators	6	1 290
Poor non-cultivators	32	804
Medium-scale farmers	99	1 036
Large-scale farmers	161	1 345

Marketing systems

Almost two thirds of the producing households sell some milk. At first glance marketing conditions appear to be very simple: the milk reaches the consumers through two separate and well-defined systems. One of these is entirely in private hands: the milk is collected from the producers by private buyers or vendors, who transport it to Bangalore city and sell it to retailers. The milk vendor often advances short-term loans to the producer and supplies him with concentrates on credit. It



Collecting mixed feed from a distribution point. The use of concentrate feed for milch animals varies among the different socio-economic groups.

was also found that one vendor supplied cows on credit, and repayment was made through reduced milk prices.

The state government intends to put an end to this system of marketing on the grounds that the buyers allegedly use their position as creditors vis-à-vis the milk producers to make large profits. It is also claimed that the buyers often adulterate the milk and thereby exploit the consumer as well. The government's solution, which is the second marketing system, is that all the functions of the middlemen — collection, processing and distribution — will be carried out through milk producers' cooperatives, milk-collecting routes, chilling centres and government dairies. In the long term, the whole marketing system is to be organized through a corporation owned by the primary producers' cooperatives. In this system it is assumed that the cooperatives will be operated by the milk producers working in collaboration and exercising democratic control, and that in addition to promoting social justice this strategy would increase the production of milk in the rural areas and the marketing of good quality milk in the city, thereby eliminating all the ills of the private marketing system.

An analysis of the real situation, however, shows that there is no sharp division between the two marketing systems. On the contrary, they are often closely integrated. Even where this is not the case, the new cooperative system has many of the traits characteristic of the traditional system, especially at the village level.

About one third of the milk-selling households, primarily large-scale farmers, sell directly to a cooperative. A quarter of the households sell to private buyers, and the milk reaches the consumers entirely through private channels. The milk from the remaining households (42 percent) is marketed through a combination of the private and the cooperative marketing systems.

Integrated marketing systems

The most common integrated marketing chain works as follows: the producers sell the milk to a private buyer who then sells it to a local cooperative, from which it is taken to Bangalore Dairy. There are, however, several variations, of which a few examples are described below.

The private buyer acting as middleman between the producer and the cooperative is usually a big local farmer, who is often also one of the leaders of the cooperative, generally the chairman or the secretary. The majority of the producers, on the other hand, are small or medium-scale farmers who produce and sell only limited quantities of milk. The relation between the cooperative leaders (who buy the milk in their own name and resell it to the cooperatives) and the producers is exactly the relation between the "real" traditional private buyers and the producers, both as regards the settling of accounts and the provision of loans and concentrates. The profit made by the cooperative office holders, calculated on the basis of data collected during the present survey, averaged 7 paise[2] per litre out of the price paid to the producer (which varied between 80 and 90 paise per litre).

Precise data on the profits made are not available — partly because the milk is also diluted along the "chain" in this marketing system.

Another type of integration between the traditional and the cooperative marketing systems was found in three of the cooperatives. In these, a private buyer, unconnected with the cooperatives, buys milk from the farmers and sells it to the cooperatives at the price stipulated by Bangalore Dairy minus a commission charged by the cooperative leader. The operation of this type of integration between the two marketing systems is dependent on the relationship between the price stipulated by Bangalore Dairy and the one prevailing in the open market.

The cooperative marketing system also has many traits characteristic of the private system. This is especially true of its relationship to the producers. The cooperative leaders often lend money to the small producers who have to pay it back when the milk is delivered. Several cooperative leaders have been accused of the kind of misuse which was supposed to take place in the private system — e.g., underpayment, failure to settle accounts, late payment, use of oversized measuring cups, refusal to pay for one day every month (a local custom practised by private buyers).

But the cooperative leaders have an edge over the traditional private buyers. Usually their local political position is much stronger, and they have more means at their disposal, not least from the development resources made available to the cooperatives. Each cooperative has the right to receive a certain amount of subsidized concentrates, especially valuable in times of rapidly rising prices. Institutional loans for the purchasing of crossbred cattle are also channelled through the cooperatives.

[2] 100 paise = 1 rupee

Conclusions

There is no doubt that increasing the numbers of crossbred cows will increase total milk production, and thereby the most important aim of the dairy development policy may be fulfilled; to supply enough milk to the growing urban centres. But if this were the only aim, dairy development would merely add to what has been called the urban bias of planning.

The present study of dairy development in south India has shown that current programmes, and the techniques applied in conjunction with the institutional framework being developed, are unlikely to meet all the stated objectives. This may be partly explained by local circumstances, i.e., by prevailing social and agricultural conditions. However, the knowledge gained from this study provides a basis for a more general discussion of dairy policy in south Asia, and perhaps in other developing regions as well.

The first question relates to the introduction of a new type of animal, the crossbred cow, into the rural areas. It is highly unlikely that crossbreeding will in time transform the low-yielding Indian local cows into high-yielding dairy cattle; it is much more likely that the two stocks will exist side by side.

Secondly, with the present emphasis on crossbred cows, the possibilities of developing dairy farming with other kinds of animals have been neglected. The Indian farmer has a long tradition of raising milch buffaloes, and these, together with goats, represent a population which requires much less working capital and skill, and which would be more suitable for the small farmer and the landless labourer than other classes of stock.

Thirdly, there is the question of the proper location of dairy development programmes. In the villages surveyed, the farmers were reluctant to use their irrigated land for fodder production. Also, from a social point of view, it could be argued that the intensive crop production areas should be reserved for food production, and that dairy husbandry should be developed in the large areas with less favourable conditions for crop production, thereby serving also as a tool for regional development.

On the institutional side it is quite clear that cooperatives have been brought to the village from "above," but apparently with little devotion to the idea behind the cooperative movement. Instead of bringing about a new structure in the village, as has occurred in other parts of India, the cooperatives have been absorbed into the nonegalitarian social structure.

Other programmes for promoting milk production in rural areas might also be envisaged. But it is questionable whether they would be able to solve the problems of the vast majority of the socially and economically weaker sections of the Indian rural population. If these programmes are not accompanied by changes in social structure they are more likely to contribute to the process of social polarization in rural India.

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The economic problems of milk schemes in developing countries

In recent years a large number of milk schemes have been launched, strongly supported with technical assistance, cash subsidies, donations of equipment and supplies of skim milk powder and butter oil. Yet many of these schemes have so far failed either to justify the investments or to improve milk supplies. This article looks at the economic problems that have been frustrating progress and that might be more effectively tackled in future by new initiatives in policy and management.

by M.G. Fenn

A major problem for new urban milk schemes, especially in Asia, has been persistent competition from the established sellers of raw milk. Private milkmen, who can collect raw milk in the surrounding countryside and arrange prompt distribution in the urban centres, normally operate on lower margins than the milk schemes which have processing costs and heavy overheads to cover. It is also difficult for the milk schemes to match the personal services which these traders provide, especially in their door-to-door collection and delivery and in giving cash advances to producers and credit to consumers.

Because little capital investment is needed and entry to this traditional trade is relatively easy, competition tends to be keen. Although profits may be moderately raised by dilution or skimming of the milk, the milkman soon loses business to others if he does not take care to satisfy his suppliers or customers. "Malpractice" is an overworked word in discussions on the traditional milk trade, and critics often underrate the efficiency of the system in terms of costs and services.

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The bicycle is an efficient means of transport for milk over short distances in Mali.

Close and objective study of the traditional milkmen's performance would be instructive for any new milk scheme which is entering competition with them. In 1966-67, the activities of the *cycle-dudhias* in an area serving the New Delhi market were studied in detail by Nightingale (1969). His report reveals a notably low-cost system with the milk traders working in trust and good relations with the local village suppliers and with their urban customers. This is one of the few research studies which has systematically compared the costs of modern and traditional systems in the same country. The main conclusions are given in the table.

The marketing costs recorded for the three categories of cycle milk sellers represent 8 percent of the price paid by the consumers.

However, the limitations of the traditional systems are equally impressive. Apart from their shortcomings in terms of hygiene, their range and scale for each urban area are restricted by the need to move raw milk from cow to customer within a few hours. Usually this means that supplies cannot be collected beyond the several miles that can be covered daily on a bicycle or a cart. The use of public transport or private motor vehicles can sometimes extend the range, but the time factor and the risks of delays and spoilage limit the possibilities.

In the past this problem had to be overcome by keeping milch cattle within the cities, and bringing fodder in from the countryside instead of milk. This is a costly method which is increasingly difficult to sustain as cities are modernized and space becomes more valuable.

Formerly, cattle were kept in cities as diverse as London and Valetta, but for reasons of public health and town planning, as well as economy, the system now survives in relatively few large cities. It is still an important feature in parts of Asia, especially in India and Pakistan where the entrenched position of the city cattle owners and their strong links with consumers add to the economic problems of the modern milk schemes.

Countervailing advantages of a milk scheme

In collecting its raw milk supplies, a milk scheme is not normally obliged to compete with the traditional trade on the same ground: it has the advantage of being able to organize collection at longer range and can thus tap cheaper sources of supply. Modern milk schemes, with their investment in bulking and chilling equipment, are indispensable for extending the development of dairy farming to distant rural areas, wherever there is good production potential. They have the capacity to stimulate liquid milk output from underdeveloped dairying areas, where producers have had to turn their output into lower value products such as ghee in order to find a market. To make the best use of this advantage, a milk scheme needs a relatively large scale of operations and a high degree of organization, otherwise its overhead costs are excessive.

At the market end, the main potential advantage of the milk scheme over the traditional sector is its capacity to improve the form and quality of the milk and to introduce a new range of processed dairy products to expand its market. But to realize this advantage the scheme has first to persuade the consumers that its products are superior and desirable.

Customers may prove unwilling to abandon their traditional sources of supply — and the milk scheme has sometimes proved incompetent in promoting its own products and in creating a public image of purity and reliability.

Delivering milk to the Amul cooperative collecting centre in India. A dairy cooperative can provide assured outlets and regular cash payments.

The income level of the prospective customers is of crucial importance here. Milk is not only a highly desirable food but also a relatively expensive one. In poorer communities, many housewives can afford it only in its cheapest form and cannot pay a premium for assured quality and packaging.

The profitable sector of the market

Consequently the best market openings for a milk scheme are to be found among the wealthier sectors of the community which are able to pay higher prices for controlled quality and good presentation and are also ready to buy fresh cream, butter, ice cream and other relatively expensive items that the plant may produce at a good profit.

A milk scheme concerned with maximizing its profits would therefore be inclined to concentrate on the high-income sector of the market. In a number of countries this is seen with private schemes which have introduced Tetrapak or ultra-high temperature milk, and a range of dairy products for marketing through supermarkets and high-class groceries. Public milk schemes should also be fully alert to the scope for increasing their throughput and revenue, and their total contribution to development, by building up profitable sales of luxury items.

But obviously a public milk scheme which directed too much of its resources toward upper income markets would be neglecting a part of its basic purpose. In the major Indian cities, for example, the declared objective of the milk scheme investments is to extend the supply of cheap and wholesome milk to the maximum number of consumers. Accordingly, great efforts are being made to develop techniques for safe but low-cost distribution systems. The Indian Dairy Corporation is not neglecting the opportunites of profitable sales of relatively expensive dairy products to those who can afford to pay, but it has to put the main thrust of its efforts behind the largely social aim of extending milk supplies to the less affluent citizens. The Indian city milk schemes are in fact attempting to adapt modern dairy technology to the needs of very low-income mass markets. This is a bold endeavour which appears to be without precedent. Normally the successful establishment of a modern milk scheme, with its heavy investments in plant and equipment, is associated with a much higher level of consumer purchasing power than is found in the Indian cities. The standard technology and equipment are designed to produce superior products at suitably related prices. In India, the need is to improve the organization, quantity and quality of milk supplies at the lowest possible price, and the larger milk schemes aim to do this by simplified processes and economies of scale.

COMPARISON OF COSTS OF MARKETING MILK IN MODERN AND TRADITIONAL SYSTEMS, INDIA, 1967

		Plant A	Plant B	Plant C
		Litres		
Modern plants	Daily capacity	300 000	60 000	6 000
	Daily sales	161 800	45 100	2 300
		Rupees		
	Marketing cost per litre	0.149	0.215	0.426
		Large category	Medium category	Small category
		Litres		
Cycle milk sellers, in Mehrauli district near Delhi	Daily sales	165	64	27
		Rupees		
	Marketing cost per litre	0.067	0.104	0.176

Problems of price policy

The demand for fresh milk, especially in lower income markets, is very responsive to price changes, and so the careful setting of sales prices is an important managerial decision. Yet in practice price fixing is normally done not by the milk scheme management but by the government itself, and often the management has no voice in the decision. Unrealistic directives on producer and consumer prices are responsible for some of the most serious economic problems of milk schemes. In Sri Lanka, for instance, for some years the government ceiling on the Dairy Board's selling prices was so low in relation to farm milk prices that the milk plants could not possibly cover their total costs. Annual losses had to be underwritten by a general subsidy. Such a situation must have a demoralizing effect on the management and limit the scope for innovations and improvements.

Moreover, where market demand is keen, undue restriction on the milk scheme's selling prices gives an unfair advantage to the raw milk sellers, whose real prices cannot be properly controlled. The Kuku milk scheme in the Sudan has been prohibited from increasing its selling prices, and in consequence it cannot pay competitive prices to its associated dairy farmers. They, in turn, are tempted to sell to the raw milk pedlars who can offer better terms.

Other milk schemes, as in Kenya recently, have been placed in difficulties by a government decision to raise producer prices to an extent that they stimulate an excessive supply. For the sake of efficient operations, it is important that a milk scheme should

be allowed considerable flexibility in its price setting for suppliers, otherwise it cannot hope to regulate its intake to match market needs and to offset seasonal fluctuations.

There are also strong economic grounds for basing producer prices on delivery-to-milk-plant, and setting farm or collecting centre prices in relation to distance and transport costs. The flat price system, which governments often prefer as appearing more equitable to producers in all areas, can involve the milk scheme in heavy costs on milk brought from greater distances. A differential price system, related to transport costs, encourages a more economic development in suitable locations.

Wherever milk prices are a matter of national importance, it is clear that the government will take ultimate responsibility for price policy. It is equally clear that if prices are set on social or political grounds, without regard for the economic needs of the milk scheme, considerable damage can be done to dairy development prospects.

Carrying milk to a chilling centre in Nepal

Welfare aims versus commercial needs

Price policy is just one of the areas in which commercial viability can be compromised by other considerations. It is a particular feature of public milk schemes that — more than other agricultural processing projects — they must face difficulties in reconciling commercial efficiency with social welfare responsibilities.

From the planning stage onward, the scheme will be expected to some degree to bring noneconomic benefits, especially in contributing to better nutritional and public health standards. There may be plans to supply free or cheap milk to underprivileged or needy groups. To help them to fufil their noneconomic aims, milk schemes have commonly been assured of special help in the development period, whether from their own government, from UNICEF, from the World Food Programme or from bilateral aid sources.

Thus, the normal economic investment criteria are not strictly applied to new milk schemes. Generous elements of subsidy are admitted for a development period on the assumption that afterwards the economic and social welfare benefits of the project together will justify the initial aid. However, the development period has too often been loosely defined, with no cut-off term after which the scheme is expected to pay its own way, and with no clear arrangement for accounting for such items as maintenance costs, amortization of plant and equipment and capital service charges.

In a number of instances, donated supplies of skim milk powder and butter oil for recombining in the plant have been a major feature of this assistance. The intention is that funds generated by sales of the recombined milk shall be devoted mainly to programmes for building up local raw milk supplies to the plant, to the point where these supplies meet the plant's full capacity requirements. But the extent to which this assistance has so far served to stimulate local milk supplies has been disappointing. The sponsors of some of the projects have been proved grossly overoptimistic in their planning assumptions, especially on the milk production potential of the area concerned, on the prospective demand for fresh milk or on the skill and efficiency of those executing the scheme. After several years, in some cases, the central plants are still heavily dependent on the supplies donated from abroad to maintain their throughput. There is evidently a danger that assistance, which was intended to expedite full development, may serve as a continuing prop for unsuccessful policies and unenterprising management.

At the same time, the need for clear economic planning in the scheme is obscured and objectives become blur-

red and confused. Basically, a successful milk scheme must be a commercial operation and its management should be clearly responsible for economic objectives.

The ideal would be to distinguish precisely any social welfare activities which the scheme is required to undertake and to make them the financial responsibility of the government, not of the milk scheme. If, for example, there was to be a programme of supplying school milk at low prices, the government would direct the milk scheme to undertake the supply as its agent and would pay it the full commercial cost of the operation. On grounds of efficiency and managerial responsibility, this is preferable to making the milk scheme directly responsible for activities

PHOTO: A.W. MARSDEN

Above: Dairy farmers bringing their milk to a collecting centre in Pakistan. Left: Cattle housed in a typical city dairy in Calcutta.

which do not cover their costs. In the latter case, the losses have to be either recovered out of margins earned on other operations, or (more frequently) the scheme's overall deficit has to be met by the government through a general subsidy.

Welfare programmes, if they are correctly distinguished and properly financed by the government as suggested, can significantly help the milk scheme by increasing its throughput and adding assured market outlets. Other operations, which are not classified as welfare services, ought to be handled on normal commercial lines as far as possible, with the management fully responsible for using efficient methods.

Problems of management and limited autonomy

The final problem to be considered here, and one of the most intractable, is that the milk scheme management may be unable to choose and apply efficient methods. This could be because the manager lacks the authority or because he lacks the ability. The scarcity of good and enterprising managers is a fact which need not be laboured. But it is associated with the more subtle problem of how to give the managers of public sector enterprises the authority, incentives and independence of action necessary for them to fulfil tasks which are essentially commercial.

In the milk industry in most Latin American countries the problem is avoided, because the milk schemes are mostly run by private companies, or by cooperatives of relatively large-scale farmers. In the developing countries of Africa and Asia, however, private enterprises are not prominent in this area of business and major milk schemes are usually part of the public sector development programmes. In a few countries the schemes are run as government services, directly responsible to the appropriate ministry. More often a statutory board, commission or government agency has been created to

give the scheme more flexibility in financial and staffing matters than is possible in a direct government department. The need is to combine public responsibility on the one hand with commercial enterprise and efficiency on the other, and there is still a long way to go in evolving forms of organization to serve both of these purposes.

The establishment of a dairy board or similar authority to run the scheme does not necessarily give a good framework for efficient commercial operations. The board members are usually nominated by government ministers and are mostly senior civil servants conveying the ministerial view. It is not normally feasible to arrange for the direct representation of producers and other interested groups on the board. On corresponding boards in developed countries, where farmers are better organized and more articulate, it is often the elected representatives of those who depend on the success of the scheme who help ensure a continuous pressure for efficiency and improvement. It is not easy to reproduce this stimulus under conditions in the developing countries.

Restrictions

Through a nominated board, the government often keeps a heavy hand on the running of the scheme. The management may not be allowed to set prices or to control staff appointments and salary levels. It may be given directives on milk collection and distribution arrangements. Financial and investment policy is largely outside its control and, if the scheme receives external assistance, this is necessarily channelled through government offices. In extreme cases, the manager is left with relatively little to manage and serves in practice as an administrator of the scheme for the appropriate government ministry. The manager appointed by the government is, in fact, often a senior civil servant who has neither the authority nor the inclination for the enterprising style of leadership that is needed for the successful development of the scheme. Appointments of this kind may be no more than secondments for a limited period with inevitably bad effects on planning and continuity of management. The milk scheme at Lahore in Pakistan had five successive managers in its first three and a half years.

Study of the public sector milk schemes in various Asian and African countries suggests that ineffective management, due sometimes to the shortcoming of the managers themselves and more commonly to the restrictive terms under which they are made to work, is one of the most serious problems of dairy development. Given the limited options open to most of the countries in this field, there is no clear solution to the problem, but, somehow or other, ways of improving the present arrangements and standards must be evolved.

Cooperatives

It is significant that in India the two milk schemes most widely acclaimed (Amul at Anand and Dudhsagar at Mehsana) are both cooperative enterprises. Their sustained progress under first-class management has demonstrated how public responsibility can be combined with commercial efficiency. To a large extent they avoid the obstacles of bureaucracy and politics that have handicapped the government milk schemes, and their direct responsibility to their producer-members preserves the incentive for success. At the International Dairy Congress held in India last year, Thakur (1974) and others presented striking evidence of the relatively good performance of the cooperative milk schemes in comparison with the government schemes. Meanwhile, the Kenya Cooperative Creameries (although developed under special conditions) provides the leading example of a successful milk scheme in Africa. In the Republic of Korea, too, milk supplies for Seoul are being rapidly developed through the Seoul Cooperative Milk Scheme.

Admittedly, overall experience of agricultural producers' cooperatives in developing countries has not been encouraging; but, on the other hand, milk marketing is a special case and modern dairy industries in countries from Scandinavia to New Zealand have been largely developed on a cooperative basis. Especially where dairying is based on small-scale farming, cooperation among producers in collection, storage, transport and processing can give special advantages and incentives to efficiency, provided that good management is assured.

When the methods and traditions of cooperation have to be built up from the beginning, solid progress is inevitably slow if the vital principle of producer control is to be fostered.[1] The logical first stage is the formation of simple cooperatives based on collecting centres, which may be equipped and run with government assistance as in Morocco. The Indian Dairy Corporation now has a special task force to help form primary cooperatives of this kind in selected areas where the producers show interest. The ultimate aim is that these village units will coalesce into large cooperative unions capable of acquiring and managing their own milk plants, as in Anand and Mehsana.

The way to such a goal is certainly difficult and probably slow, but the policy does promise a solution to the hitherto intractable problems of managing milk schemes in the public sector. Perhaps developing countries will increasingly adopt the view of the Scandinavians that, in dairy development, cooperatives are "the only way."

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[1] For a criticism on socioeconomic grounds of some of the dairy cooperatives promoted by the Indian state governments, see Nyholm, Schaumburg-Müller and Westergaard in this issue.

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development of the JAMAICA HOPE breed of dairy cattle

by K.E. Wellington and P. Mahadevan

Apart from the Taylor breed of India, which was evolved a century ago as an interbreeding population of high producing crossbred cattle (Henderson, 1927), and the newly developed Australian Milking Zebu (Hayman, 1974), the only other tropical dairy breed that has been successfully produced from a *Bos taurus* × *Bos indicus* crossbred foundation is the Jamaica Hope. This breed, which is supported by a breed society, has some 6 000 registered females and is fairly widely distributed throughout Jamaica. The demand for Jamaica Hope animals from other tropical countries is growing. Some animals have been exported to countries within the Caribbean area as well as to Latin America, but the growing demand can only be met by the export of bulls and semen. This article is concerned with the origin and development of Jamaica Hope, its performance characteristics, the breeding policy currently adopted and the lessons to be learnt for new breed development elsewhere.

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Origin

The first phase of development of the Jamaica Hope breed began in 1910 with the testing of various European cattle and their grades under Jamaican conditions. The Government of Jamaica established a dairy herd at its Hope Farm, near Kingston, with Ayrshire, Brown Swiss, Guernsey, Holstein Friesian, Jersey and Red Poll cattle as well as crosses of these to cattle of mixed type (i.e., animals containing creole and zebu blood). This was followed in 1920 by the introduction of Sahiwal genes into the population through one bull im-

Group of Jamaica Hope cows

ported from Pusa, India. There was insufficient evidence at that time to determine which of the European breeds was likely to contribute most successfully to the dairy industry of Jamaica. However, it soon became evident that the six imported European breeds could not all be tested on the same farm, and those with the poorest performance were eliminated at an early stage. The Ayrshire and Brown Swiss showed little promise over the Holstein Friesian and Jersey and were therefore removed in 1928. Red Poll breeding for milk stopped in 1938, although these animals continued to be used for beef breeding and contributed to the development of the Jamaica Red breed of beef cattle.

The second phase commenced in 1943, when it was decided to discontinue Guernsey breeding; the average age at first calving among Guernseys was 42.1 months and the mean calving interval was 14.9 months. The gene pool of the animals at the Hope farm was broadened through importation of more Jersey bulls, and considerable attention was also paid to the improvement of husbandry practices and to the testing of sires on the basis of progeny performance. The sires in service in 1943 were four imported purebred Jerseys and five Jersey-Sahiwal crosses ranging from 3/4 Jersey 1/4 Sahiwal to 1/8 Jersey 7/8 Sahiwal. The grade Jersey females varied in their inheritance from 1/4 Jersey 3/4 Sahiwal to the equivalent of four topcrosses of Jersey (Lecky, 1962). The average age at first calving among grade Jerseys was 38.3 months and that of purebred Jerseys 35.8 months. With improvements in feeding and management the overall mean was reduced to 32 months. Calving intervals averaged 14.2 months. The highest lactation yields were produced by grade Jerseys with 5/8 to 7/8 Jersey inheritance.

The breeding of Holstein Friesians was terminated at the end of the second phase in early 1952. The reasons for this were as follows. Although the half-bred Holstein Friesians gave higher milk yields than the Jersey crossbreds, there was a significant decline in yield as the level

high-producing cows could be selected as dams of herd sires for the genetic improvement of the breed

1. *Sam's Nymbrook. Born June 1957. First lactation 3 922 kg milk in 305 days. Highest lactation 9 343 kg in 305 days. Total milk yield 48 279 kg in seven lactations.*

2. *Stalin's Victory Noris. Born November 1959. First lactation 5 449 kg milk in 305 days. Highest lactation 9 079 kg in 305 days. Total milk yield 56 704 kg in 10 lactations.*

of Holstein Friesian blood increased. The culling rate was highest among animals of Holstein Friesian breeding, and this increased with the proportion of Holstein Friesian inheritance. The mean age at first calving was 42.1 months, and calving intervals increased in length from a mean of 15.2 months for all animals to 17.2 for three-quarter breds. Milk production per acre was also regarded as being lower among grade Holstein Friesians than among grade Jerseys.

TABLE 1. National milk records of Jamaica Hope cattle (1965-73) based on the Dairy Herd Improvement Scheme

Year	Average lactation milk yield	Average lactation length	Number of herds	Number of lactations
	kg	*days*		
1965	2 102	268	34	1 228
1966	2 265	258	47	2 055
1967	2 319	262	49	2 571
1968	2 390	271	35	1 639
1969	2 544	272	32	1 468
1970	2 603	269	33	1 575
1971	2 620	268	42	1 812
1972	2 571	266	52	2 277
1973	2 551	266	46	1 958

Elevation to breed status

In 1950, the cattle at Hope Farm were transferred to the Bodles Animal Research Station and thereafter bred as a closed herd. The commencement of the third phase, in 1952, was marked by an official ceremony at which all the animals at the Bodles Station and those of similar genotype on privately owned farms throughout Jamaica were elevated to breed status. The basic population then consisted of both purebred and grade Jerseys, as well as of selected animals from the Holstein Friesian breeding programme. The grade Jerseys were those that had acquired genes for adaptation to a tropical environment through the admixture of zebu blood during the period 1910 to 1952; their lower age at first calving, shorter calving intervals and smaller body size, as compared with other animals, were regarded as evidence that under Jamaican conditions they would be more economical producers of milk than the general run of Holstein Friesians and their derivatives. The few animals of Holstein Friesian breeding that were incorporated in the breed were those that were descendants of matings to the foundation family of Norbrook Jerseys.

The third development phase, which is represented by the period 1952-64, involved considerable attention to breed development within the nucleus herd at Bodles. Sires were selected on the basis of dam and progeny performance and no attempt was made at fractional breeding. The breed stabilized at a level of about 80 percent inheritance from the Jersey, 15 percent from the Sahiwal and 5 percent from the Holstein Friesian. Impressive production records were achieved by individual animals; notable among these were Sam's Nymbrook (Figure 1) and Stalin's Victory Noris (Figure 2). The most outstanding cow was Stardust, which produced a lifetime record of over 70 000 kg milk in 12 lactations.

The period 1964-74 may be regarded as the fourth phase in the life of the breed. During this period, efforts to increase the population of Jamaica Hope cattle and the total amount of milk produced were not significantly successful. The breed recorded lower levels of production in the Bodles herd, but some breed society members who participate in the breeding and registration of Jamaica Hope cattle improved their levels of husbandry and achieved higher production than was possible at Bodles. Enthusiasm for the development of the breed was lacking and cattle of Holstein Friesian breeding were imported in an effort to meet the island's need for fresh milk.

These importations likewise failed to make the impact envisaged and emphasized the need for improved husbandry, irrespective of breed.

TABLE 2. Production parameters of Jamaica Hope cattle at Bodles and in six farmer herds

Trait	Bodles (1950-64)		Farmer herds (1960-66)	
	Number of records	Mean	Number of records	Mean
Age at first calving	903	34.2 months	368	35.9 months
Length of lactation	2 153	322 days	1 634	324 days
Length of calving interval . .	1 751	439 days	1 394	405 days
305-day milk yield	2 153	3 218 kg	1 665	2 755 kg
Milk yield per day of lactation	2 131	10.9 kg	388	10.0 kg
Milk yield per day of calving interval	1 654	8.2 kg	308	8.2 kg
Butterfat content	879	4.88%	—	—

SOURCE: Wellington *et al.*, 1970.

3. *Nancy's Malan, the sire with the highest contemporary rating. Born November 1959 and used extensively.*

Breed performance

National milk production records covering the period 1965-73, computed through a locally based Dairy Herd Improvement Scheme, are set out in Table 1 for the Jamaica Hope breed. Selected herds of the breed in Jamaica were also recorded through the Dairy Herd Improvement Association of the United States Department of Agriculture, and the records processed in North Carolina. For 12 herds so recorded, the average 305-day milk yield based on 2 158 records was 2 737 kg, with a mean butterfat yield of 130 kg and a butterfat content of 5 percent. These figures are rather higher than the national average.

Earlier studies (Wellington *et al.*, 1970) carried out at the Bodles herd and in six cooperating farmer herds provided the parameters set out in Table 2. The Bodles herd averaged 3 218 kg milk in 305 days as compared with 2 755 kg for the farmer herds. A larger sample of herds belonging to 34 breed society members was also recorded over the period March 1967 to February 1968 to determine the effect of variations in husbandry practices on milk production. The herds were first classified as good, mediocre or poor, according to level of management, and then recorded. Their 305-day milk yields averaged 2 905, 2 000 and 1 623 kg respectively. These results confirmed the view that the breed had a reasonable potential for milk production under tropical conditions, but that good husbandry practices were essential for this potential to be realized.

Studies of individual herds showed considerable variation in age at first calving and in the length of the calving interval. The mean age at first

TABLE 3. Relationship between age at calving and first lactation milk yield at Bodles (1950-64)

Age at first calving	Number of records	Mean milk yield
Months		*Kg*
21-24	7	2 095
25-29	106	2 750
30-34	331	2 832
35-39	181	2 786
40-44	60	2 859
45-49	27	2 895

semen from Jamaica Hope bulls like the three pictured here is available for export

4. *Wogloire. Born October 1961 and used extensively.*

5. *Golden Citation. Born August 1965 and used extensively.*

calving ranged from 33.1 to 42.4 months and the calving interval varied from 371 to 466 days. The relatively late age at first calving highlighted the need to improve the nutrition of heifers, the control of internal parasites during early life and conception rate. Research currently in progress aims at breeding heifers at 15-18 months of age to facilitate a mean first calving of 27 months. It is not expected that this will cause a significant decline in yield in the first lactation, as evidenced by the relationship between age at calving and first lactation milk yield in the Bodles herd (Table 3). Furthermore, with a mean birthweight of 24 kg for female calves and a demonstrated rate of liveweight gain of 0.45 kg per day to age at first service (McLaren, 1966), it should be possible for heifers to be successfully mated at a body weight of 225-250 kg for calving at 27 months, even if this requires two services per conception. The lowering of the mean calving interval to 400 days or less would call for concerted efforts to reduce the service period. Greater attention to the nutrition of animals in early lactation, mating at the first heat following 60 days after calving and improved heat detection are likely to pay the best dividends.

From a disease standpoint, the Jamaica Hope has the advantage that it was exposed to tick infestation right through its formative stage and that all animals of the breed, both in the Bodles herd and elsewhere, were raised in an environment where anaplasmosis and piroplasmosis occurred. As a result, it has developed a remarkable degree of tolerance to these diseases.

Breeding policy

At the inception of the breed, two criteria of selection were established: production performance and fertility. To date, no conscious selection for colour or type has been practised (see photo page 27). In recent years it has become evident that udder conformation and quality should be included in the overall criteria of selection.

Selection of female breeding stock on the basis of their production performance has been negligible among Jamaica Hope cattle since the time of breed formation (Roache *et al.*, 1970). This is understandable in a situation where breed development continues to be based on a relatively small population, where involuntary wastage is encountered and where the need to increase numbers is crucial. Voluntary selection among females would tend to be minimal in these circumstances. However, the selection of cows as dams of herd sires offers greater opportunities for the genetic improvement of the breed.

Thus, cows with a minimum production of 4 545 kg (10 000 lb) milk in a 305-day lactation are currently selected as dams of potential herd sires and these cows are usually mated to proven bulls. Selection between sires is then made on the basis of their own progeny tests.

Selection and testing

For many years, the entire population of Jamaica Hope cattle depended on the Bodles herd for sire service as well as for the evaluation of sire performance. The restriction of progeny testing to Bodles was found to hamper the further development of the breed (Mahadevan *et al.*, 1970); the number of daughters per sire was often too low for an accurate assessment of its breeding value, and too few sires could be tested to give an adequate intensity of selection. It therefore became evident that all farmers should be involved in testing, by using young sires extensively through artificial insemination and milk-recording their daughters. Selection and testing of sires over a wider cross-section of the total population is now in progress, employing either natural service or artificial insemination and analysing the results using contemporary comparisons. The number of daughters per sire on test, however, continues to be small and the method is therefore used only as a screening device for culling the poorest of the young sires. Some of the sires that have been more extensively used are shown in Figures 3-5.

Although some 50 breed society members maintain Jamaica Hope cattle, the degree of enthusiasm required for the further development of the breed is lacking within the country.

The future

Most of the commercial cattle enterprises in the island do not participate in breed development; they change their breeds all too often and tend to vacillate between dairy and beef operations. In recent years, a large number of Holstein Friesian cattle have been imported into Jamaica from North America. Unless Jamaica Hope breeders are prepared to meet the demand for more breeding stock and improve their levels of efficiency, there is every prospect that this breed, like the Taylor breed of India, might be of only historical interest in the decades to come.

It would be relevant in this context to investigate the feasibility of an exchange of breeding stock between the recently developed Australian Milking Zebu and the Jamaica Hope, which have been evolved from similar foundation stock. If this could be organized, it would help provide a wider genetic base for both breeds. Several important lessons may be learnt from Jamaican experience for new breed development elsewhere, if such development is desired. The first relates to the initital problem of deciding which breed or breeds should be used for crossing. If the aim is to obtain not merely the highest yield of milk but the highest "overall dairy merit" and the highest market return under the prevailing local conditions, a single experimental herd would normally be inadequate for the testing of several breeds. Secondly, even after the choice of breed has been made, it would be unwise to confine the work on new breed development to one herd, except perhaps in the formative stages. A large number of sires (at least 10-15) of the chosen breed would need to be tested annually, and herd size thus becomes a limiting factor once again. It is therefore essential that the programme should be extended as early as possible to other herds; a large cow population is required for the effective progeny testing of a large number of sires and for the intense selection for traits of economic importance that must be practised. Jamaican experience also highlights the fact that unless the herds participating in the programme are efficiently milk recorded and become involved in the testing, by using young sires extensively through artificial insemination, their inclusion will not contribute materially to breed development. Indeed, in course of time, they should themselves be able to offer sires for testing and in this way broaden the scope for selection. Continued improvement from new breeds requires further selection within these populations. Without the cooperative efforts of a number of participating farmers, a relatively small nucleus of animals of a new breed developed within a single herd is unlikely to make any significant impact in a time span of 20 to 25 years.

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MINIMUM CONCENTRATE FEEDING
for efficient milk production

by J.W. Hibbs and H.R. Conrad

Voluntary feed intake is the major factor limiting milk production from cows with a potentially high yield

High farm production costs and the growing worldwide competition between animals and man for cereal grains dictate the use of minimal amounts of concentrate feeds for lactating cows, commensurate with efficient utilization of available forages. As shown by Conrad *et al.* (1964) the amount of feed a cow can eat in a 24-hour period is limited by the indigestible residue (faeces) in the digestive tract, when ration digestibility is below about 67 percent. When digestibility is above this figure, factors other than indigestible residue limit voluntary feed intake. Therefore, in cows that possess the genetic capability for high milk production, feed intake is a major limiting factor.

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Forage quality

On this basis then, the best indicator of forage quality is the amount of digestible forage dry matter or digestible forage energy a cow can eat per 24 hours per unit of metabolic body size ($BW^{0.73}$). This takes into account percent digestibility and rate of digestion, as well as size of animal and any influence palatability or acceptance may have on voluntary feed intake. The factor which influences forage quality to the greatest extent is the stage of maturity of the plant when harvested either as pasture or for hay or silage. The effect of stage of maturity on digestibility, voluntary forage intake and milk production is illustrated in Table 1 (Conrad *et al.*, 1961). As the forage matured, digestibility, voluntary dry matter intake and milk production declined.

The dry matter of alfalfa-brome forage declined in digestibility at an average rate of 0.26 percent per day (1.8 percent per week) between the alfalfa prebud stage on May 17 (when it was 66.8 percent digestible) and the mature stage on June 28 (when it was only 55.8 percent digestible). During this period, 4 percent FCM (fat-corrected milk) production dropped from 42.5 lb (19.3 kg) to 19.5 lb (8.9 kg) in Jersey and Holstein cows when they were fed this forage free choice (green-chopped from the same field), with only 4-7 lb (1.8-3.4 kg) of concentrate per day. The drop in milk production is an indication of the reduced digestible forage intake, which declined from 23.0 to 14.7 lb (10.5 to 6.7 kg) per 1 000 lb (454 kg) of body weight. Faecal dry matter, the limiting factor on intake, remained constant, despite the changes in digestibility and intake. The reduction in forage quality with advancing maturity is an

EQUATION 1

$$\text{Total dry matter intake (lb)} = \frac{\text{Body weight (lb)}}{1\,000 \text{ lb}} \times \frac{10.7 \text{ Faecal dry matter}}{\text{1 minus the percent digested (expressed as decimal)}}$$

EQUATION 2

$$\text{Maximum feed intake (lb)} = 10.7 \times \frac{W}{1\,000} + 0.056\ W^{0.73} + 0.33\ M + 0.53$$

EQUATION 3

$$\text{Minimum allowable digestibility (\%)} = \frac{0.056\ W^{0.73} + 0.33\ M + 0.53}{\text{Maximum feed intake (lb)}}$$

important consideration where forage is cut and fed daily, compared to the practice of harvesting at a certain stage of maturity and feeding from storage as silage or hay.

Prediction of dry matter intake

In a large number of Ohio digestion trials, it was found that cows fed high roughage dairy rations excreted in the faeces an average of 10.7 lb (4.9 kg) of indigestible dry matter per day per 1 000 lb (454 kg) of body weight, when digestibility was below about 67 percent and voluntary feed intake was therefore limited. Thus, dry matter intake, when digestibility is below about 67 percent, can be predicted by using Equation 1 if body weight and ration digestibility are known (Conrad, 1965, 1966).

A 1 400-lb (636 kg) cow fed a 65 percent digestible high roughage ration would therefore be able to consume 42.8 lb (19.5 kg) of dry matter in a 24-hour period. For any given high-roughage ration, the average factor of 10.7 lb (4.8 kg) per day per 1 000 lb (454 kg) of body weight for faecal dry matter will vary somewhat depending on the rate of digestion in the rumen and particle size.

By combining the estimate of faecal dry matter from Equation 1 with Brody's (1945) equation for estimating TDN (total digestible nutrients) intake multiplied by 1.1 to convert to digestible dry matter intake, formulae for calculating maximum feed intake and minimum allowable digestibility for maximum feed intake were derived (see equations 2 and 3, where W = body weight in lb and M = lb of 4 percent of fat-corrected milk).

The sparing effect of high quality forage on grain requirements for milk production is clearly shown in Table 1; only 4.7 lb (2.1 kg) of grain plus free choice feeding of the highest quality forage (66.8 percent digestible) on May 17 was enough to maintain 42.5 lb (19.3 kg) of milk per day; but by June 28, 6 weeks later, when forage digestibility had declined to 55.8 percent, it was calculated that 18.2 lb (8.3 kg) of grain would have been required to maintain the initial level of milk production. This suggests that a sound basis for optimum supplementation of forages with grain concentrates would be to add only sufficient balanced grain concentrate to bring the total ration digestibility to 67 percent, the point where digestibility no longer limits intake.

In addition to the sparing effect of good roughage on feed grain requirements for milk production, it is possible to meet all the supplemental protein needs of high-producing cows through the use of high protein forages. Table 2 shows that when 60 percent protein alfalfa dry matter was fed with 20 percent maize silage dry matter, only 20 percent grain dry matter (with no protein supplement added) was needed to support 305 day lactations of 17 000 lb (7 727 kg) of milk. When the high protein alfalfa was reduced to 42 percent of the ration dry matter intake and 16 percent maize silage dry matter was fed, it required double the grain dry matter (42 percent) containing 19 percent protein to support this level of milk production.

The extent to which a high protein grain mixture should be used instead of high protein forage for high producing cows will depend upon the relative availability and cost of each. Either system can be used successfully to attain high levels of production if cows of high milk producing potential are fed.

TABLE 1. Effects of stage of maturity of green-chopped alfalfa-brome forage [1] on digestibility, forage intake and milk production

Stage of maturity	Harvest date	Dry matter digestibility	Dry matter intake	Digestible dry matter intake	Faecal dry matter	Milk production	Amount of grain needed [2]
		Percent	*lb/day* [3]	*lb/day* [3]	*lb/day* [3]	*lb/day*	*lb/day*
Alfalfa							
Pre-bud	May 17	66.8	34.0	23.0	11.1	42.5	4.0
Bud	May 24	65.0	33.2	21.6	11.6	39.5	5.7
Early bloom	May 31	63.1	32.0	20.2	11.8	31.4	8.4
Mid-bloom	June 7	61.3	30.6	18.8	11.8	31.4	10.9
Full bloom	June 14	59.4	29.2	17.4	11.8	26.5	13.5
Late bloom	June 21	57.5	27.8	16.0	11.8	23.4	15.7
Mature	June 28	55.8	26.3	14.7	11.6	19.5	18.2

[1] Fed free choice with 3 to 5 lb (1.4 to 2.3 kg) grain concentrate per day to Jersey and Holstein cows. — [2] Estimated amount of grain needed/1 000 lb (454 kg) cow/day to have maintained the level of milk production on May 7. — [3] Pounds per day per 1 000 lb of body weight.

TABLE 2. Lactation performance of high-producing Holstein cows fed different protein supplements

Protein supplement used with high quality alfalfa	Feeds used			305-day lactation	
	High protein alfalfa	Maize silage	Grain concentrate	Milk	Fat
	Percent [1]			*Pounds*	
No protein supplement in concentrate [2]	60	20	[2] 20	17 761	524
Soybean meal	42	16	[3] 42	17 462	575
Dehy-100 (2/3 alfalfa, 1/3 urea) [4]	42	16	[3] 42	18 051	626
Soybean meal	25	25	[3] 50	18 172	692

[1] Percent of total ration dry matter. — [2] Concentrate was ground maize and minerals only. — [3] 19-percent protein concentrate. — [4] 100-percent crude protein equivalent.

TABLE 3. Effect of level of grain feeding on digestibility, intake and milk production when fed with free choice soilage from the same field [1]

	Soilage [3]		
Grain, dry matter (lb/d) [2]	0.0	4.0	7.6
Soilage, dry matter (lb/d)	28.2	26.5	24.5
Dry matter digestibility (percent)	63.5	69.1	67.5
Digestible D.M. intake (lb/d)	17.9	21.1	21.7
Protein digestibility (percent)	78.6	75.8	74.0
Weight change (lb)	+13.0	+36.0	+40.0
4 percent corrected milk (lb/d)	30.5	34.8	34.1
	Silage [4]		
Grain, dry matter (lb/d) [2]	0.0	3.3	6.9
Silage, dry matter (lb/d)	20.0	20.9	18.6
Dry matter digestibility (percent)	55.3	58.5	60.6
Digestible D.M. intake (lb/d)	11.1	14.2	15.5
Protein digestibility (percent)	63.6	65.6	63.5
Weight change (lb)	—57.0	—53.0	—13.0
4 percent corrected milk (lb/d)	22.7	28.7	30.5

[1] Data from Ohio Agr. Exp. Station Res. Bull. 871-Jan 1961. 1958 data. — [2] Grain was equal parts by weight of oats and ground ear maize-11.2 percent protein. — [3] Soilage fresh chopped daily – alfalfa-brome – from early May to Sept. fed free choice. — [4] Silage made between June 4 and 13 from parts of the same fields from which soilage was cut – fed free choice.

An important factor to keep in mind in choosing the level of grain feeding to use with the available forage, especially when grain feeding must be limited because of economics, is that the first few pounds of grain fed, even with the best forages, yield the greatest return in milk production. Much of this is the result of increased digestible dry matter intake. This is illustrated in Table 3 which shows the results of an experiment (Pratt *et al.*, 1961) in which different levels of grain were fed to dairy cows (24 Jerseys and 6 Holsteins — average initial body weight 424 kg), that were receiving either free choice soilage (green chopped alfalfa-brome) from early May to September, or free choice silage made from the same fields during the period June 4-13.

It can be seen that when 4 lb (1.8 kg) of grain was added to the free-choice soilage ration, a marked increase in milk production of 4.3 lb (2 kg)/day resulted. When an extra 3.6 lb (1.6 kg) of grain was added there was no further increase in milk production. It is significant that the first 4 lb (1.8 kg) of grain raised the digestibility of the ration to above 67 percent so that intake was no longer limited and the increased digestible dry matter was reflected in increased milk production.

When free-choice silage was fed, milk production increased at both levels of grain feeding. This was because of the lower digestibility of the silage which caused total ration digestibility to be below 67 percent at both levels. The increases in milk production were a reflection of the increases in digestible dry matter intake from 55.3 to 58.5 and 60.6 percent respectively. Thus, additional increments of grain would be expected to raise milk production until sufficient grain had been added to

TABLE 4. Effect of alfalfa-brome forage maturity on its nutritive and dollar value

	Harvest date, Wooster	Total protein	Digestible protein	Digestible protein	Net energy	Non-protein net energy	Value of digestible protein per ton [1]	Value of non-protein N.E. per ton [1]	Total value per ton [1]
		Percent		*lb/ton*	*Mcal/ton*	*Mcal/ton* [2]	*Dollars*		
Alfalfa									
Pre-bud	May 17	21.9	16.9	338	1 240	742	78.82	38.81	117.63
Bud	May 24	18.9	14.1	282	1 120	704	65.76	36.82	102.58
Early bloom	May 31	15.9	11.3	226	1 040	706	52.70	36.92	89.62
Mid-bloom	June 7	14.0	9.5	190	960	680	44.31	35.56	79.87
Full bloom	June 14	12.0	7.7	154	900	673	35.91	35.20	71.11
Late bloom	June 21	10.0	5.8	116	760	586	27.05	30.65	57.70

[1] When maize costs $100 per ton and soybean meal costs $200 per ton. — [2] Digestible protein contains 1.4755 Mcal (therms) of energy (N.E.) per pound.

raise ration digestibility to about 67 percent.

It is therefore evident that, unless grain is unavailable, a major increase in milk yield can be expected from only a few pounds of grain per day and that the more digestible the roughage fed the sooner the point of diminishing return from grain feeding will be reached.

The same principle applies to the use of pasture, except that cows do more selective eating on pastures, thus regulating intake to higher quality (more digestible) forage than when the whole plant is harvested and fed. Pasture management systems have been devised for maintaining high quality forage throughout the grazing season (rotational grazing — strip grazing — top grazing). However, the feeding of a few pounds of cereal grain [4-6 lb (1.8-2.7 kg)/day] can be expected to give a good response in digestible dry matter intake and milk production, even when excellent pasture is available. Grains that are for various reasons not suitable for human consumption, along with cereal by-products, offer a significant source of high-energy feeds to supply the relatively small amounts needed for this initial response. Grain feeding beyond this level should be determined by the quality of the available forage and the economic advantage to the dairyman based on price of grain and price of milk.

Main dairy barn at the Ohio Agricultural Research and Development Centre, Wooster, Ohio, United States.

Feed processing and storage facility at Wooster. Experimental rations formulated by nutrition researchers are prepared here and delivered to the various barns.

Forage farm barn at the Centre. Cows used in research on pasture and other forage are housed here.

It should be emphasized that when high-quality forages are fed or grazed it is possible to supply all the protein needs of high producing cows through the forage, as shown in Table 2. As forage quality declines, the concentrate mixture must supply more and more nitrogen, either as protein or non-protein, as well as energy to balance the ration. In general, the grasses have a slower rate of digestion resulting in somewhat lower digestible dry matter intake per day than legumes such as alfalfa.

Table 4 shows the digestible protein and net energy content of the alfalfa-brome forage previously discussed under Table 1 and illustrates the effects of stage of maturity of the forage on these important nutrients. As the alfalfa-brome forage matured, the protein content declined rapidly from 21.9 percent on May 17 to 10.0 percent on June 21. This resulted in a

drop from 338 lb (154 kg) of digestible protein per ton to 116 lb (53 kg) per ton. Net energy during this same 6-week period declined from 1 240 to 760 megacalories (Mcal) per ton, and non-protein net energy from 742 to 586 Mcal per ton. These data emphasize the fact that high-quality forage makes a major contribution to the energy needs of livestock in addition to its high protein content.

Relative cost of feeds

In practice, the price paid or charged for forage often does not reflect its actual nutritive value. If we disregard the value of minerals and vitamins A and D, the monetary value of forages must be considered in terms of the relative cost of other feeds which can be used to supply protein and energy in dairy rations.

An intensive system called top grazing, where cows graze a restricted area of alfalfa and ladino clover for 3-4 days, leave 20-25 cm of quick recovering growth and move on to the next plot, to return after about 22 days for regrazing, has proved to be an inexpensive method for harvesting over 725 kg of protein per acre and sustaining high milk production with no supplemental protein needed.

The grazing season can be extended from five to eight months under Ohio conditions by using orchard grass for early (April) and late (October and November) grazing together with top grazing of alfalfa-ladino clover (May-September).

The basis for the derivation of formulae for calculating the value of a pound of digestible protein and a megacalorie of non-protein net energy was described in the Ohio Report of November-December 1968 (Conrad and Hibbs, 1968). Maize was used as the basis for energy, and soybean meal as the basis for protein values.

Mathematically stated, the formula for calculating the value of 1 lb of digestible protein in forages or other feeds when soybean meal costs $200 per ton and maize $100 per ton is shown in Formula 1. The value of 1 lb of digestible protein was calculated by dividing the cost of 100 lb of soybean meal minus the cost of the quantity of maize containing the amount of non-protein net energy in 100 lb of soybean meal, by the number of pounds of digestible protein that could be ascribed to the difference in their costs.

Thus, when maize costs $100 per ton and soybean meal costs $200 per ton, 1 lb of digestible protein in forages or other feeds is worth 23.3 cents. The value of 1 Mcal (therm) of non-protein net energy was calculated as shown mathematically in Formula 2. This was done by calculating the cost of the quantity of maize containing the amount of non-protein net energy in 100 lb of soybean meal. The cost of the digestible protein in this amount of maize (using the value of a pound of digestible protein as calculated in Formula 1) was then deducted. The resulting value was then divided by the number of megacalories (Mcal) of non-protein net energy (N.E.) in 100 lb of soybean meal.

Thus, when maize costs $100 per ton and soybean meal costs $200 per ton, a megacalorie (therm) of non-protein net energy is worth 5.2 cents. Both formulae may be adjusted to fit any price combination by inserting the desired dollar or other currency values for maize and soybean meal.

Table 4 also shows the changes in monetary value of the digestible protein and non-protein net energy in the forage as it matured, when maize is worth $100 per ton and soybean meal worth $200 per ton.

FORMULA 1

$$\frac{(100\text{ lb} \times \$0.1000) - (33.112\text{ lb} \times \$0.0500)}{35.78\text{ lb}} = \$0.2332 \text{ per lb digestible protein}$$

FORMULA 2

$$\frac{(33.112\text{ lb} \times \$0.0500) - (1.623\text{ lb} \times \$0.2332)}{24.42\text{ megacalories}} = \$0.0523 \text{ per Mcal non-protein N.E.}$$

In using these dollar values, it is assumed that the feeds are completely consumed in a balanced ration, with no credit given to the value of the minerals and vitamins A and D.

The declines in protein and energy with advancing maturity are reflected in the monetary values. For instance, on May 17 the digestible protein in a ton of alfalfa-brome forage was worth $78.82 and the non-protein net energy was worth $38.81. By June 21, 6 weeks later, the digestible protein value had declined to $27.07 and the non-protein net energy to $30.65. The decline in total value of the digestible protein and non-protein net energy during this 6-week period was from $117.63 to $57.70 per ton.

When the decline in digestibility and nutrient content of the forage with advancing maturity is considered, along with the effects of these changes on feed intake, milk production and monetary value in relation to other feeds, the importance of harvesting when the forage is immature cannot be overemphasized. This is especially important when the forage is to be fed to high-producing cows or when cereal grains and their by-products are in limited supply or when the cost is excessive. From the agronomic point of view a suggested realistic goal for producing forage for dairy cattle and other ruminants is the maximum production of estimated net energy (ENE) per acre per year. ENE can be calculated from total digestible nutrients (TDN). Using Moore's formula based on Morrison's TDN and ENE values (Moore *et al.*, 1953), ENE = (1.393 × TDN) — 34.63.

Summary

Voluntary feed intake is the major limiting factor on milk production in potentially high-producing cows. Below about 67 percent ration digestibility, feed intake is limited by the indigestible residue in the digestive tract. Thus, both digestibility and rate of digestion are important factors in determining feed intake on high roughage rations. The first few pounds of a balanced grain concentrate [4-6 lb (1.8-2.7 kg)] added to an all roughage ration which is below 67 percent digestibility can be expected to increase milk production as a result of both its stimulating effect on rate of digestion in the rumen and increased ration digestibility which results in increased digestible dry matter intake. Additional amounts of grain will result in further increasing digestible dry matter intake until digestibility of the ration is raised to about 67 percent. Above about 67 percent digestibility, factors other than ration digestibility and rate of digestion limit intake.

A ration digestibility of about 67 percent therefore represents the critical level for minimum grain feeding to attain maximum forage intake. The advisability of feeding grain above about 67 percent digestibility of the ration is determined by the ability of the cows to respond in increased milk production and by the availability of grain and its cost in relation to the price of milk.

Perhaps the best indicator of forage quality is the amount of digestible forage dry matter or digestible forage energy a cow can eat in a 24-hour period per unit of metabolic size ($BW^{0.73}$). This takes into account both digestibility and rate of digestion, as well as the size of the animal and any influence palatability or acceptance may have on voluntary intake. Stage of maturity of the forage plant influences its quality as a feed more than any other factor; as maturity advances the protein content declines and the energy becomes less available. This markedly reduces its monetary value as feed for cattle and other ruminants. A method for calculating the value of the digestible protein and non-protein net energy in forages based on the net energy value of maize and the digestible protein value of soybean meal is used to show how the value of alfalfa-brome forage declines as it matures. From the agronomic viewpoint maximum production of estimated net energy per acre per year is a suggested goal for producing forages for dairy cattle and other ruminants.

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Waste cellulose as an energy source for animal protein production

by I.A. Dyer, E. Riquelme, L. Baribo and B.Y. Couch

Cattle eating paper ration

The feeding of high proportions of grain to fattening cattle needs to be reevaluated in view of the prevailing low world food reserves and the low availability and high cost of feed grains. The abundance of cellulosic feeds derived from agriculture and other sources makes such reevaluation all the more necessary. In the United States alone, the amount of agricultural cellulosic waste available in 1946 was estimated to be 1.73×10^8 tons (Ott, 1946) and since then it has increased markedly. At present, the world's cellulosic waste, including paper and agricultural waste, is estimated to be 100 thousand million tons per annum (Microwaves, 1974). Forest cellulosic waste, like agricultural waste, occurs in abundance in many parts of the world and is a renewable resource.

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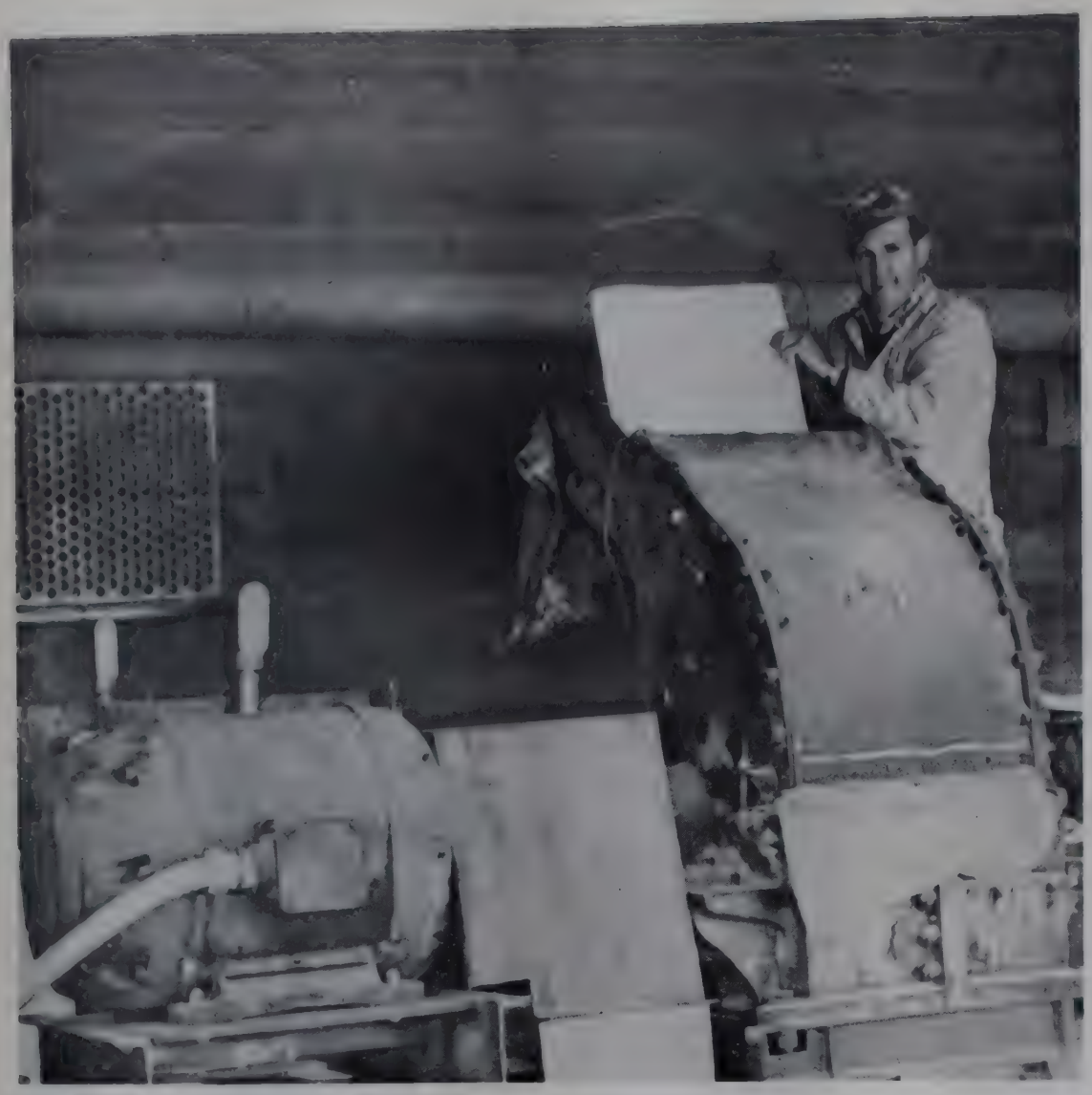
Unprocessed cellulosic feeds

The potential of cellulose as an energy source and the utilization of unprocessed cellulosic feeds in limited amounts by ruminant animals have been known for many years and are discussed in several texts (Hungate, 1966; Gould, 1969). Pu-

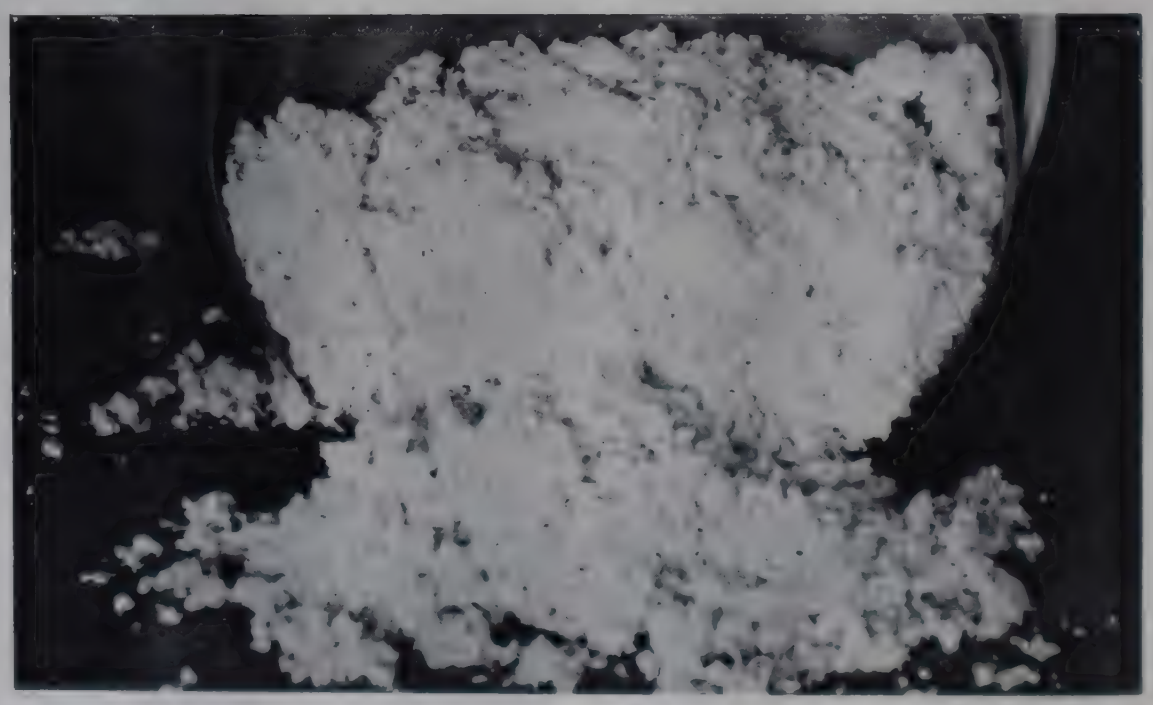


Paper passing through hammermill

Domestic animals generally compete with man for cereal grains and it is not economically feasible for the relatively inefficient ruminant animals to compete with the more efficient non-ruminants and man for high cost grains. Researchers, aware of the problems, have utilized forages and cellulosic waste, derived from agriculture and other sources, primarily to provide roughage in finishing cattle rations. Even though the incorporation of unprocessed cellulosic materials as roughage in high concentrate ruminant rations (to maintain the "normal" physiological functioning of the rumen) is practical, it does not fully utilize the potential of cellulosic feeds as an energy source and does not spare the use of cereal grains.

Processed cellulosic feeds

In order to increase the utilization of straw, hay and other cellulosic materials and make them acceptable as a primary energy source of ruminants, several processes have been investigated. These processes vary in their degree of complexity and include soaking, fine grinding, pelleting, irradiating with high energy



Ground paper

rified cellulose is equal to, if not better than, sucrose as an energy source for ruminants (Nehring *et al.*, 1965); but the net energy density of unprocessed or native cellulose fibres is low. The lower nutritional value of unprocessed cellulosic products is due to the low digestibility of the carbohydrate portion of these materials and can be largely attributed to their lignin content (Van Soest, 1969) which may be as high as 15 percent in mature forages. In wood and wood by-products, the lignin content may be twice this level. Lignin acts not only as a diluent of the rations because of its indigestible nature, but also as a barrier which prevents cellulose breakdown by the ruminal microorganisms because of its close association (physical and/or chemical) with cellulose. The concept of breaking the ligno-cellulose bond and the removal of part or most of the lignin has been used primarily in the pulping industry. Less interest has been shown in conditioning cellulosic material for animal feeds, except in situations when other feeds were scarce (Hvidsten and Presthegge, 1941; Nordfeldt, 1947; Nehring and Schramm, 1949).

electrons and chemical degradation. It appears that chemical degradation of the cellulosic materials offers the highest quality end-product at the lowest cost. The chemical procedures for lignin removal are by no means new. Beckmann (1922) reported that treating straw with a 1.5 percent NaOH solution resulted in a twofold increase in the amount of crude fibre utilized by ruminant animals. This procedure, however, required large volumes of NaOH solution and wash water. In more recent studies, the original Beckmann procedure has been modified into a "dry" process in which smaller quantities of more concentrated NaOH solutions are used to treat straw or low quality hay. In determining the optimal level of NaOH for treating straw, it has been observed (Donefer *et al.*, 1969) that *in vitro* digestibility of cellulose increases in direct proportion with NaOH concentration until the NaOH level is 8-10 g/100 g straw. Higher concentrations of NaOH result in a decreased rate of cellulose digestion. If the NaOH treatment is carried out at pressures greater than atmospheric pressure, the duration of treatment or the level of NaOH can be decreased to obtain the same or higher rates of cellulose digestion than those observed under atmospheric pressure.

Although NaOH has been the most common chemical used to delignify feedstuffs, several other chemicals have also been used. Butterbaugh and Johnson (1974) compared the nutritive value of rations containing acid hydrolyzed wood residue with that of alfalfa meal in lamb fattening rations. They observed that rations containing up to 75 percent low acid hydrolyzed wood residue (0.8 percent H_2SO_4) were consumed well by growing lambs and that weight gains were not affected with wood residue levels of 25 or 50 percent. Utilization of high acid hydrolyzed wood residue (2.3 percent H_2SO_4), however, was limited by palatability if fed at levels higher than 35 percent of the ration and weight gains were decreased even at the 20 percent level. Clark and Dyer (1973) investigated the value of chemically degraded wood as an energy feed in finishing beef cattle rations. The wood utilized was Douglas fir, processed by an adaptation of the sulfite pulping method described by Nordfeldt (1947). In this experiment, steers fed the 70 percent chemically degraded wood ration had a lower average daily gain (ADG) than steers fed a 70 percent barley ration (Table 1). This difference in ADG was not significant, probably due to the large variation in ADG within treatments (C.V. = 30 percent). The 70 percent chemically degraded wood ration contained 12.5 percent lignin, which was probably responsible for the

Horizontal food mixer

Feeding mixed ration

TABLE 1. Performance of finishing cattle fed sulfite degraded wood

Item	Ration	
	78% barley	70% wood
Number of steers .	6	6
Initial weight, kg .	326.4	322.7
Final weight, kg .	460.9	396.4
Daily gain, kg . .	1.07	0.59
Daily intake, kg [1] .	6.29	6.20
kg feed/kg gain . .	5.89	10.58

SOURCE: Clarke and Dyer (1973).
[1] Dry matter intake of barley-fed steers was adjusted to equal that of the wood-fed steers.

lower ADG. The overall performance data indicate that even though the energetic value of the Douglas fir pulp does not compare with that of barley, it is approximately equal to a medium quality hay.

Energy value

Further studies conducted with sulfite pulps have indicated that, when lignin is almost completely removed by sulfite cooking, washing and bleaching, so that the residual lignin content is less than 1 percent, the resulting product has an energy value approximately 85 percent that of barley for fattening lambs (Riquelme *et al.*, 1975). In this and other trials (Table 2) in which a 66 percent sulfite pulp ration has been compared with a 60 percent alfalfa ration, no differences in weight gains of lambs have been detected. In cases where sulfite pulp has replaced barley in the fattening rations, a slight decrease in ADG has been observed. The average daily feed intake of lambs fed the sulfite pulp also decreased. This reduction in voluntary feed intake has also been observed in other trials where different cellulosic materials, such as newsprint (Daniels *et al.*, 1970), sawdust (Anthony *et al.*, 1969) or chemically degraded wood (Clarke and Dyer, 1972), have been fed to ruminants and it does not seem to be associated with the palatability of the ration. Sherrod and Hansen (1973) attribute the lower feed intake of rations containing newspaper to an increased ruminal fill and lower turnover rate of rumen contents. One of the factors that contribute to the increased fill is the high water-holding capacity of cellulose fibres and the consequent greater water retention within the rumen.

When high quality sulfite pulp is fed, the decreased feed intake is still noted, but the similar ADG observed has resulted in higher efficiency of feed utilization by the animals. Carcass composition studies have shown differences between lambs fed the sulfite pulp and those fed conventional rations; the latter deposited proportionally more fat in their carcasses than the pulp fed lambs. Protein deposition in the carcasses of lambs fed sulfite pulp was higher than in lambs fed the 60 percent alfalfa ration (Table 2). But no differences were detected in protein deposition in carcasses of lambs fed sulfite pulp or barley rations. The observed differences in composition may be an additional factor affecting feed efficiency. Insofar as animal protein production is concerned, the potential of processed cellulosic waste to supply the energy required for animal growth and production is essentially unlimited. If a 70 percent processed cellulose ration were fed to cattle or sheep, an average of 8 g of edible protein will be produced per kg of feed (assuming 50 percent dressed weight and an average of 13 percent carcass protein). Therefore, the energy required to provide 100 percent of an estimated 5.98×10^{10} kg world's annual protein need could be met through waste-cellulose feeding to cattle, sheep or goats if only 5 percent of the world's waste cellulose could be collected and processed.

The potential of processed cellulosic waste to supply the energy needed for animal growth and production is unlimited. These cattle are eating rations containing newsprint.

Mineral, vitamin and protein supplementation

The removal of lignin from cellulosic wastes may necessitate a more careful evaluation of the entire rations. During the delignification process and subsequent washing, many of the soluble constituents, including nutrients, are removed from the material. These would include some hemicelluloses, nitrogenous compounds, minerals and the dissolved lignin. The resulting product is composed largely

TABLE 2. Mean gain, carcass composition and efficiency of feed utilization of lambs fed standard fattening rations or rations containing cellulosic fibre

	Trial I diets [1]		Trial II diets [1]	
	60% alfalfa 40% grain	66% wood-cellulose fibre 34% supplement	70% barley 30% alfalfa	70% wood-cellulose fibre 30% supplement
Mean initial weight, kg . . .	42.3	40.7	36.3	37.6
Mean final weight, kg	56.7	52.9	54.1	50.3
Mean carcass weight, kg . .	32.1	28.1	29.0	27.0
Carcass composition:				
Protein, %	12.45	14.08	16.05	16.07
Fat, %	36.43	32.26	32.93	29.67
Efficiency:				
Total gain, kg	14.4	12.2	17.8	12.7
Mean daily gain, kg	.18	.15	.25	.18
Mean daily feed intake, kg	1.78	1.33	1.77	1.33
g liveweight gain/kg feed . .	101.0	112.0	141.0	135.0
g protein deposited/kg feed	7.71	8.37	12.13	11.63

[1] Supplements provided crude protein, minerals and vitamins to meet NRC requirements.

of cellulose and essentially devoid of many nutrients found in most feedstuffs. Rations containing high levels of these purified celluloses should be considered as semipurified diets and special attention should be given to mineral, vitamin and protein supplementation. The special supplementation required for these types of rations may be regarded by some as a disadvantage, especially the protein supplementation. Ruminant animals, however, need not compete with man (or other non-ruminant animals) for proteins, as they utilize non-protein nitrogen such as urea or buiret or protein from sources such as cottonseed meal that are not normally used for human consumption. Other advantages of using waste cellulose for animal protein production are that most people eat meat when it is available and that animal protein is of higher biological value than most plant proteins. Furthermore, beef cattle, sheep and goats are already adapted to most inhabited areas, and cellulosic waste, although not evenly distributed, occurs in most populated parts of the world.

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NEW TRENDS IN ENSILING FORAGES

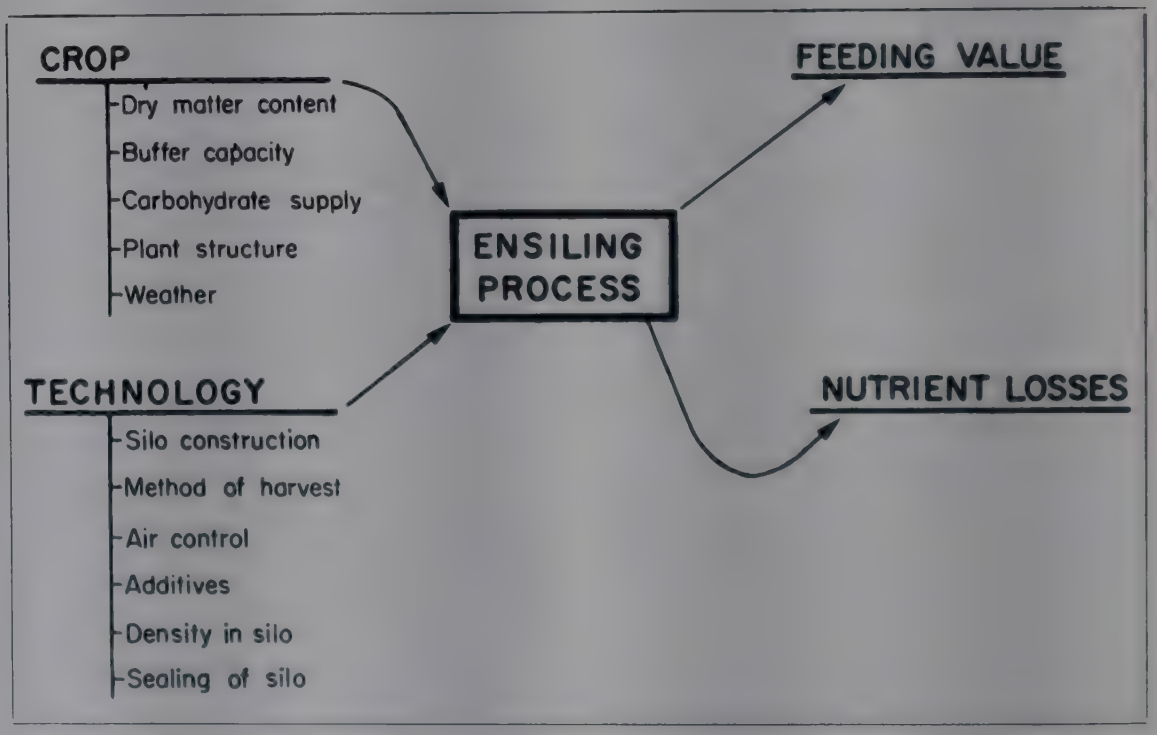
The silo is no substitute for the production and harvesting of high-quality forages

by M.E. McCullough

The main trends in silage making today are a return to the basic principles of silage fermentation and the proper supplementation of the silage to ensure maximum economic utilization. To the casual observer of livestock agriculture, these may appear to be so elementary that one might wonder why they have not been the primary aims of silage making all along.

Following World War II, silage production in the United States and other affluent countries was engulfed by the "mechanization" revolution of the fifties and sixties. What started out to be a substitution of human labour by mechanized methods of production, harvesting and storage soon became a race to see who could develop the most complicated and expensive machinery. The silage itself frequently became less important than the equipment used to handle it. Thus, the dry matter content of the crop to be ensiled was considered more in terms of silo structure and unloading equipment than in terms of the preservation of the nutrients ensiled. Unfortunately, these trends caused many developing countries either to conclude that silage was too expensive for them or to try to emulate the silage production systems in the United States with an obvious waste of valuable development funds.

1. *Factors influencing silage fermentation*



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A trench silo dug in firm soil is as useful as a specially engineered and highly automated upright. However, the silage resulting from the methods of preparation illustrated on the right will be of very poor quality: the material being ensiled is too coarse and stemmy, and compaction will be insufficient.

During the 1950s and 1960s silage production in some of the developed countries was engulfed by the mechanization revolution, resulting in the construction of expensive silos like those below.

The current energy crisis and world food shortage with the resulting emphasis on animal production from forages has created the proper climate for reevaluating silage production. Thus, this article will consider the basic principles of silage fermentation as a means for preserving forage nutrients.

What is the aim of silage making?

Barnett (1954) defined the aim of silage making: "to achieve within the ensiled mass a sufficient concentration of lactic acid, produced as a result of the presence of micro-organisms within the cut crop, to inhibit other forms of bacterial activity and thus preserve the material until such time as it is required." This basic concept includes the factors necessary for lactic acid production such as exclusion of air, availability of adequate carbohydrates, adequate moisture content and the initiation of an early and rapid fermentation. Under proper conditions, silage fermentation will result in the preservation of over 90 percent of the harvested energy and protein and the concentration of energy within the silage.

Role of the silo in silage making

Despite all the advertising and promotion designed to sell various makes and types of silos, the silo has only three functions in the ensiling process:

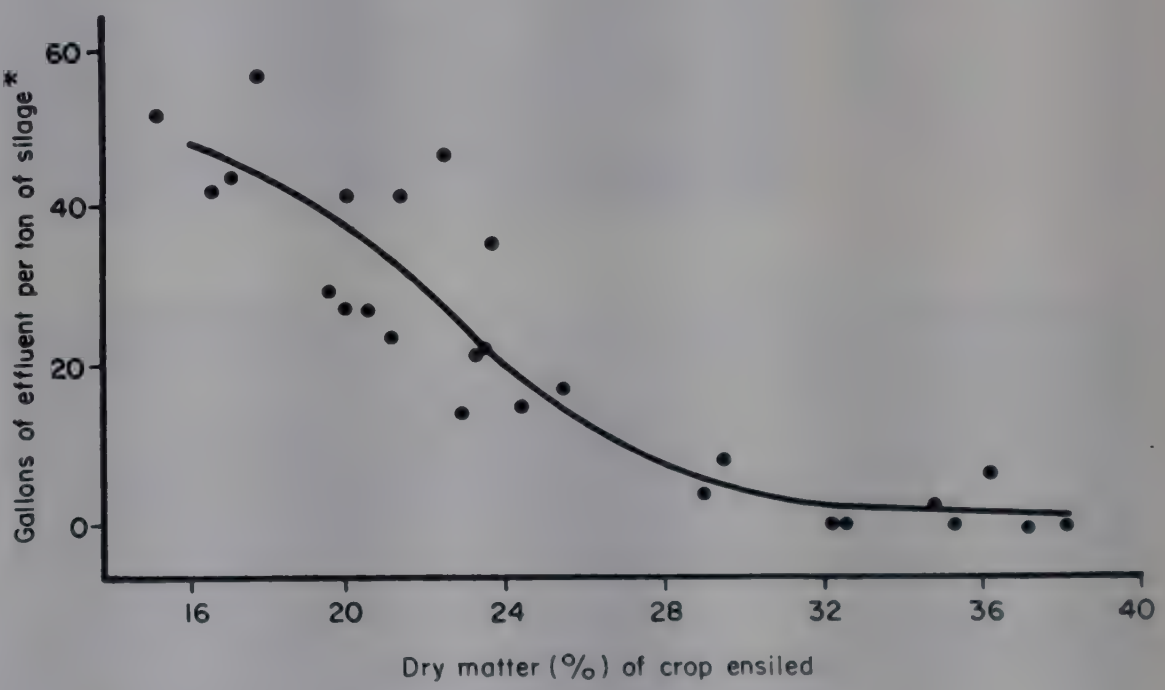
- to provide a solid surface to permit compaction of the mass to eliminate air;
- to protect the ensiled materials from air and water during the storage period;
- where desired, to aid in the removal of silage by providing a base for unloading equipment.

If the silo meets the first two requirements, the cost of its construction is of little significance. Thus, a trench silo dug in firm soil is as useful as a specially engineered and highly automated upright. The role of the silo in mechanization of silage handling should not be confused with its role in silage fermentation.

Factors influencing silage fermentation

The major factors influencing silage fermentation are illustrated in Figure 1. The successful manipulation of the factors contributed by the crop and the technology of ensiling have significant effects on the losses sustained in the silo and on the feeding value of the resulting silage.

2. *Relationship between silage dry matter content and effluent production*



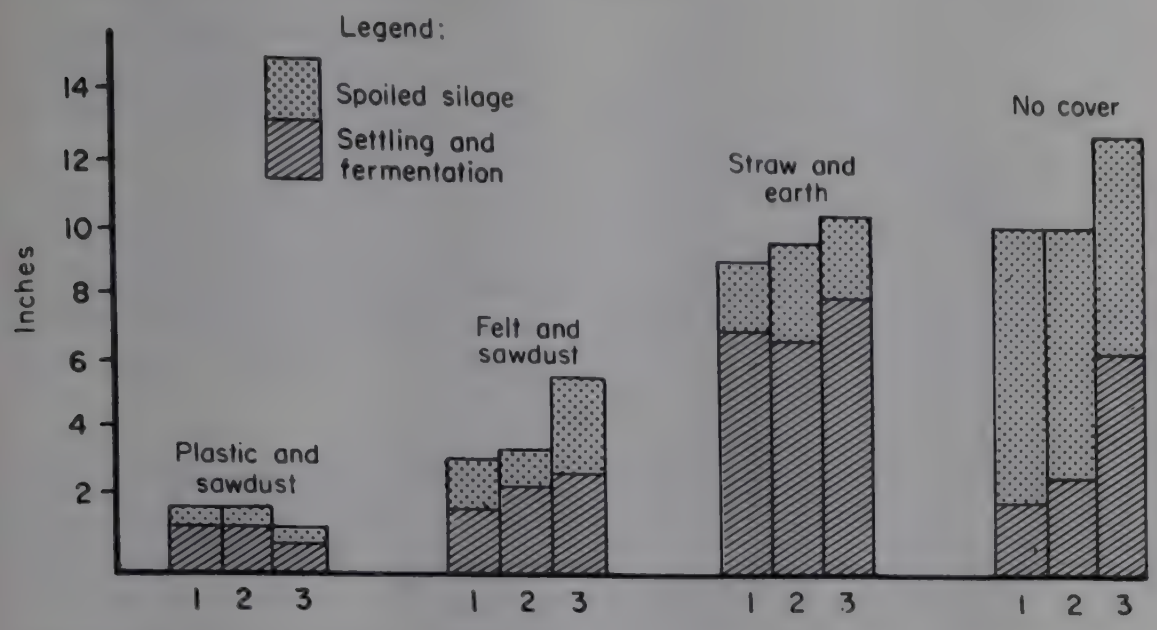
* 1 gallon equals 3.78 litres.

The crop

Since a major influence on the production of lactic acid is exerted by the crop ensiled, it is important to know the ensiling properties of the latter. The buffer capacity of the crop to be ensiled, which is largely determined by its protein and mineral content, must be exceeded by the lactic acid that is formed during fermentation. It is therefore important that the forage ensiled should be brought down to a pH level of 4.0 as quickly as possible to prevent further fermentation and to create a stable condition within the silo. Thus, legumes and high nitrate grasses are more difficult to ensile than cereals such as maize and sorghum. At the same time, forages with high protein and mineral contents are also usually low in carbohydrates. This is particularly relevant when high-moisture (above 75 percent) forages are ensiled, since the moisture dilutes both the carbohydrates available for acid production and the acid formed.

For these reasons, silages should be made from crops with at least 25 percent dry matter. Conversely, silages with insufficient moisture have an adverse influence on fermentation with the result that the optimum range in dry matter is between 25 and 35 percent. Forages should never be permitted to reach optimum dry-matter levels to the detriment of their nutritive value. It is preferable to correct for moisture by adding high dry-matter roughages than to harvest the forage at a late stage of maturity. A major problem in ensiling high moisture forage is the effluent, or "run-off" produced in the process. The data in Figure 2, compiled by Murdock (1954), show

3. *Influence of covers on spoilage in trench silos**



* Data are given for three experiments in each treatment.

that seepage was greatly reduced at more than 25 percent dry matter and almost eliminated at 30 percent dry matter. The large variations at each level of moisture were due to differences in crops and amount of material ensiled. Large silos with heavy compaction produce more effluent than small silos. Proper disposal of effluent should be considered in planning for silo construction and location.

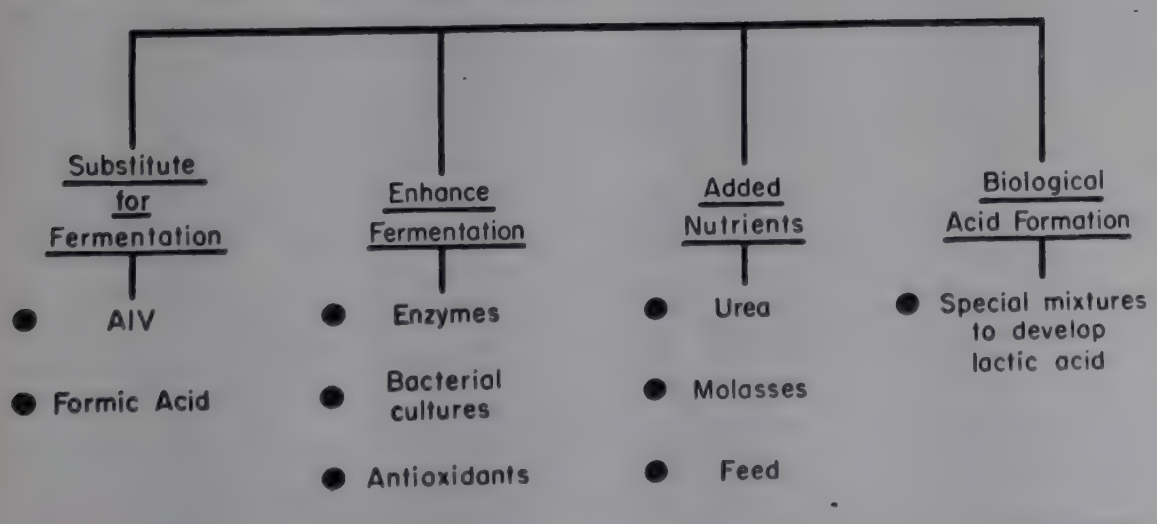
Technology

This refers primarily to the system of harvesting and storage used to eliminate air from the fresh forage ensiled and to the protection of the ensiled forage from air and water. Although a high level of technology is required in all climates, it is far more important in warm, humid climates. An important consideration in such climates is the prevention of mould growth both within the silo and in the silage prior to feeding. The primary effect of mould is a lowered rate of milk production or weight gain.

To ensure a rapid exclusion of air, forage should be chopped to an average length of 1.3 cm or less, ensiled as rapidly as possible, packed as ensiled and handled to give the maximum density possible under existing circumstances. The exact methods for doing this can only be decided in terms of conditions existing on a given farm at a given point in time. For this reason, it is not profitable to try to set down rules for any and all conditions. Since silage cannot always be easily compacted, every effort should be made to do a fast and thorough job within the restrictions of the farm situation.

A major failure in silage technology, particularly in warm, humid areas, arises from lack of protection of the silage mass after ensiling. Owen and Miles (1956) in Mississippi demonstrated the need for and effectiveness of silo covers. Their data in Figure 3 is of particular interest, since it illustrates losses under warm, humid conditions. The use of straw and earth was of little value, since it permitted rain water to permeate the silo. The felt and sawdust cover was also found to be inadequate. A heavy plastic, covered with sawdust, reduced spoilage by 88 percent, and was a very economical use of both labour and money in the silage-making process.

4. *The mode of action of silage additives*



Silage additives

Silage additives are usually included as a part of the technology of silage making. However, due to the current economic value of additives and the wide range of their use, an understanding of the mode of action or classification of additives is essential. The four basic forms are illustrated in Figure 4. Traditionally, silage additives have been considered as useful tools for silage-making in cool, wet climates where legumes are part of the silage mixture. In recent years, new emphasis has been placed on their use in warm, humid areas and with crops other than legumes. In part, this change in emphasis comes from the realization that forages grown under high temperatures must be harvested at earlier stages of maturity if they are to be of sufficient quality to result in acceptable levels of animal performance. Research in Australia by Minson and McLeod (1970) showed that dry-matter digestibility was negatively

correlated with mean temperature ($r = -0.76$) and rate of evaporation ($r = -0.64$). Thus, to obtain highly digestible forages in warm climates, forages must be harvested while they are high in moisture.

Substitutes for fermentation: Since the object of silage fermentation is the production of sufficient lactic acid to lower the pH to 4.0, an alternative would be the addition of sufficient acid at ensiling to achieve the same objective. Perhaps the best known system was developed in Finland by A.I. Virtanen. His process, called the A.I.V. system, used a mixture of sulfuric and hydrochloric acids. The system has declined in popularity since the farmer must handle strong acids, and the inorganic acids require careful mineral supplementation at feeding time. In northern Europe and several other areas of the world, formic acid has largely replaced the A.I.V. system. The change to formic acid did not remove the problem of handling acids, but it does have the attraction of being a natural acid with nutritional value. In recent years, salts of formic acid have been tried, since they can be handled in a dry form. The idea of reducing the pH by adding organic acids has proved to be a most useful method of controlling silage fermentation and will undoubtedly continue to be an alternative additive. The current energy crisis with its influence on the chemical industry may result in these additives becoming too expensive for farm use.

Enhanced fermentation: The second class of additives are those which aid the compaction of the mass, increase the rate of fermentation, and/or in some way improve the efficiency of the normal fermentation process. Included in this classification are cellulases, lactic-acid bacteria, antioxidants, fermentation residues, and miscellaneous enzymes. Although this area has frequently been indiscriminately exploited by commercial enterprises, there are mixtures available with definite biological merit. A well researched example of this type of additive is a product called *SiloGain* (NuLabs, Portland, Oregon) which consists of cultured strains of lactic acid producing bacteria originally cultured from high quality silage. Recent research at this laboratory showed that, added to wheat silage, this product reduced energy losses in the silo from 16 percent, in the control silage, to 7 percent with the additive. In maize silage, the reduction was from 25 percent in the control to 12 percent with the additive. These reductions of half the energy loss during ensiling are evidence that the normal process of fermentation can be improved. The fact that many natural silage fermentations result in excellent silage must not be equated with efficient fermentations. Since the first 96 hours in the silo are critical in determining the efficiency and success of the ensiling process, research and development of highly reliable and cheap additives that enhance this area of silage making should do much to improve the use of silage.

TABLE 1. Digestibility of forage sorghum silages

Silage additive	Dry matter	Crude protein	Crude fibre	Ether extract	NFE
	Percent				
None	53[a]	37[a]	52[a]	58[a]	57[a]
Lactic acid bacteria	59[b]	46[b]	58[b]	68[a]	63[b]
Formic acid	60[b]	49[b]	59[b]	70[a]	63[b]
Urea + molasses	58[b]	47[b]	57[b]	64[a]	61[b]
Urea + molasses + lactic acid bacteria	59[b]	47[b]	58[b]	62[a]	62[b]

Values having the same letters are not significantly different ($P < .01$).

Added nutrients: The best known additives in silage making are sources of carbohydrates and nitrogen. Since the added nutrients contribute to both the ensiling process and the nutritive value of the silage, the major question in their use is one of cost. Whenever and wherever feeds such as citrus pulp, maize, distillers' grains, molasses and similar products are available at a usable cost, they could be valuable additions to the silage making process. Animal wastes may also be usefully ensiled in combination with forages.

Biological acid formation: This is largely a new area of research and is mentioned here only to explain its possible future use. There is growing evidence that certain mixtures of products are capable of producing lactic acid through fermentation within the silo without significantly

TABLE 2. Relationships between silage quality, silage intake and average daily gain of heifers

Forage Number	Dry matter digestibility	Body weight	Digestible dry-matter intake	Average daily gains	
				Actual	Calculated
	%	*lb*	*lb*	*lb*	*lb*
1	45	383	4.7	0.26[a,b]	0.21
2	49	371	4.5	0.45[a]	0.51
3	55	347	7.1	1.17[b,c]	0.96
4	56	416	4.1	0.93[b]	0.99
5	63	348	6.0	1.40[c,d]	1.43
6	63	482	6.9	1.34[b,c,d]	1.49
7	67	393	8.7	1.64[d,e]	1.74
8	68	394	7.6	1.81[e]	1.75

Values having the same letters are not significantly different ($P < .01$).

affecting the nutrients in the original forage. In short, it is a fermentation within a fermentation. Although not ready for use in farm practice, the process does bear watching for future development.

Additives in action

Since many of the developing nations as well as many established livestock areas are in warm, humid climates, it might be useful to illustrate the classes of additives when used with forages typical of such areas. Forage sorghum is widely adapted to warm, humid climates. The data in Table 1 illustrate the comparative effects of additives with three modes of action when used with high moisture, low buffer, low soluble carbohydrate forage — in this case, forage sorghum. Comparing the control silage with any of the treated silages clearly indicates the destructive nature of the ensiling process on the feeding value of such forages. At the same time, the comparisons show that using a fermentation enhancer (lactic acid bacteria) to establish an immediate fermentation, or lowering the pH with formic acid or adding carbohydrates and nitrogen results in significant improvements in silage feeding value. The method of choice would be determined by the availability of materials and the relative costs of the alternative additives.

Table 3. Influence of grain supplements on animal performance (N = silage without additive. DG = silage with distillers' dried grains)

Item	High acetic [1]		High propionic [2]		Normal [3]	
	N	DG	N	DG	N	DG
Daily 4% milk	35.5	38.1	31.9	35.6	32.2	38.4
Percent fat	5.5	4.9	5.0	4.5	5.0	4.8
Daily total solids . .	4.31	4.75	3.93	4.48	4.00	4.70

Means	*4% milk*	*% fat*
Silos:		
No additive	34.0[a]	5.2
100 lb distillers'	37.8[b]	4.7
Rations:		
High acetic	36.8	5.2
High propionic	33.7	4.8
Normal	35.3	4.9
Preliminary production:		
No additive	42.2	5.0
100 lb distillers'	42.3	4.5

[1] High acetic — Grain ration had 16% crude protein, 72% TDN and 11% crude fibre. — [2] High propionic — Grain ration had 16% crude protein, 78% TDN and 2% crude fibre. — [3] Normal — Grain ration had 16% crude protein, 76% TDN and 5% crude fibre.

Feeding value of silage

The data in Table 2 illustrate the high correlation between the dry matter digestibility of silages, the intake of silage and the average daily gains of dairy heifers. The multiple correlation between intake, digestibility and average daily gains was +0.89. These data show that only the best available crops should be used for silage and they should be harvested and ensiled to conserve them at their optimum stage of maturity in terms of dry-matter digestibility. Since the ensiling process at its best can only preserve what was ensiled, the silo is no substitute for the production and harvesting of high quality forages.

The data in Table 3 illustrate the combined effects of using a silage additive to enhance the silage-making process and the feeding of a supplement to maximize silage utilization. The data from this laboratory are the results of ensiling maize silage with or without dried distillers' grains and the use of low- or high-fibre grain rations for milking cows. In all rations, the use of an additive significantly increased milk production due to improved silage fermentation. Within silages, using a grain ration with sufficient digestible crude fibre to ensure adequate acetic acid formation in the rumen increased both milk and butterfat production. The two factors were apparently additive in their effect on milk production since the cows receiving the high acetic type ration produced more milk than the cows on the control silage receiving the same grain ration. Current trends in silage production involve the application of known principles of silage fermentation to conserve a maximum of the nutrients ensiled. When these are combined with modern ration formulation techniques, maximum animal performance can be obtained with the resulting silage.

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ANIMAL FEEDS AND MEAT: CURRENT SITUATION AND PROSPECTS

Animal feeds

Coarse grains

Prospects for 1975 coarse grain crops have deteriorated during the last quarter, and world output, while higher than last year, is no longer expected to exceed 1973 levels. Production is presently estimated at 674 million tons, 3.8 percent above last year and almost equal to the 675 million tons harvested in 1973. Dry conditions in North America, drought in the U.S.S.R., hot dry weather in northern and central Europe and floods in eastern Europe all contributed to the lowering of crop estimates, especially for maize. Moreover, the continuing unfavourable weather, particularly in the United States cornbelt, could reduce production prospects still further in that country, the major supplier to world markets.

The supply and demand situation for coarse grains has tightened, reflecting the lower production estimates. Again, as in 1972/73, the reduction in the U.S.S.R. supply position and the consequent increase in the import requirements of that country were the main factors turning the trade outlook from easy to tight. World import requirements in 1975/76 are estimated to range between 60 and 68 million tons, compared with 57 million tons last season (66 million tons in 1973/74). Some recovery in livestock feeding is expected in the large industrialized countries, which added to U.S.S.R. requirements would result in trade near the 1973/74 level. Sufficient grains are forecast available in exporting countries to meet these requirements, but exporters' stocks are unlikely to be greatly replenished.

Carryover stocks for coarse grains have continued their sharp decline for the third consecutive year. During the crop season ending 1975 inventories have reached 41 million tons, compared to 73 million tons in 1972. At present levels stocks are near to minimum working requirements with little, if any, reserve element

World market prices for coarse grains continued to increase during August, reversing the declining trend that began in October 1974. Export prices for United States maize No. 2 yellow (f.o.b. Gulf) rose by 15 percent between early July and mid-August to $132 per ton, but still remained below August 1974 levels. At these levels, prices of cereals in animal feed rations will not be as attractive as in the earlier years of the decade and any further increase could result in a return to the unprofitable situation which prevailed during late 1974.

Oilcakes and meals

The outlook for world production in 1975/76, based on the current forecast for output of the main oilseeds, is a record level of 32.2 million tons (protein equivalent). This would be some 2.6 million tons (or nearly 9 percent) more than production in the preceding season, and over 1 million tons above the figure suggested by the extrapolation of long-term trends. The increase is virtually all accounted for by soybean meal protein.

Current indications suggest that world supplies of *soybeans* will be at record levels. In the United States, the latest crop forecast (based on conditions at 1 August) indicates a production of 39.7 million tons, which would be 6.1 million tons more than in 1974 and the second largest harvest after the record crop of 1973; with beginning stocks also heavier than last season, total supply, at over 45.5 million tons, would be the highest on record. The Brazilian crop of 1974 is tentatively assumed at 10.8 million tons, against an estimate of 9.5 million tons for this year.

Unless there is a stronger demand for animal feeds than is currently expected — coupled with possible substantial purchases of United States soybeans and/or meal by the U.S.S.R. — stocks (mostly in the form of soybeans) are expected to increase further during the season. The 12 August supply/demand estimates for United States soybeans forecast an increase in stocks during the 1975/76 season of about 4.9 million tons to reach 10.9 million tons by 31 August 1975. United States closing stocks of soybeans would then be equivalent to some 30 percent of expected disappearance during the season.[1]

Prices of vegetable oilcakes and meals have been fairly stable during the last quarter, and continued to be relatively low in comparison to those of feed grains. However, prices have shown a slight tendency to rise in late July and early August. Factors underlying this include, on the side of demand, a revived interest by traders, in part prompted by the fear that the large grain purchases by the U.S.S.R. might be extended to purchases of soybeans and/or soybean meal. On the side of supply, reports of unfavourable weather in sunflowerseed-growing areas in the U.S.S.R. and eastern Europe, of drought affecting rapeseed crops in France and the Federal Republic of Germany, and of insufficient moisture over some United States soybean areas, were contributing factors.

Meat

No further growth in cattle inventories during 1975 is expected in North America and western Europe. There will be a significant downward adjustment in the size of the breeding herds. Slaughterings of breeding stocks in the European Economic Community had already risen by an exceptional 80 percent in 1974, and statistics for the first months of the current year show another increase of about 23 percent over the corresponding period of the previous year. In North America the 1974 cow and heifer slaughter was 11 percent above the 1973 figure but the increase in the first half of the current year amounted to about 50 percent. In both areas, the 1973 cow and heifer slaughter amounted to 18 percent of the breeding stock at the beginning of the year, while this ratio rose to 20 percent in North America and 33 percent in the EEC during 1974. Next winter, fodder supplies will be short in western Europe because of widespread drought. Pasture conditions were reported to be deteriorating recently also in North America. These factors, together with higher feed grain prices, are expected to accelerate herd culling and cattle slaughterings in the late summer and early autumn in both regions. The resulting *increase in beef production* would be large.

[1] Based on the mid-point of the ranges given by the U.S. Department of Agriculture.

Cattle numbers continue to rise in other regions, particularly in the major exporting countries in the southern hemisphere and the U.S.S.R. In the U.S.S.R., livestock numbers on state and collective farms as of 1 July 1975 had increased over the previous year by 3.1 percent for cattle (of which cows 2.6 percent), 1.8 percent for pigs, 0.5 percent for sheep and goats and 2.7 percent for poultry. The rise in cow numbers shows that the base for increased meat and dairy production is also rising. The relatively small rise in sheep and goat numbers implies higher slaughter and suggests poor pasture conditions. During January-June 1975, meat production fulfilled the six-month goal and the 1975 target (revised downward in early 1975 from 16 million to 15.3 million tons slaughter weight) is within reach. But the feed situation in general might worsen if dry conditions prevail also in August. To reduce the need to import feedstuffs, the U.S.S.R. might continue to import large quantities of meat, as it did in 1974 when over 500 000 tons (400 000 tons beef) were bought.

Returns to beef producers have improved in the current year in the EEC, following the increase in the Community cattle guide price for the 1975/76 year and as a result of various support measures. They are, however, still below the trigger point for intervention purchases. There was a marked rise in cattle prices in North America in the first half of the year but they have been declining since the end of June. There will be more pressure on cattle prices in the coming months, owing to the expected heavy slaughterings while no substantial revival of demand is foreseen. Some support for cattle prices will come from the smaller availability of pigmeat. The outlook for pigmeat production has improved in recent months, because of favourable shifts in the livestock/feed price ratios which, if continued, could eventually induce an expansion in breeding stock. However, the resulting production increases would not be felt before the second half of 1976.

International sheep breeding congress 1976

A congress of scientists interested in sheep breeding is to be held to coincide with the fiftieth anniversary of the establishment of Muresk Agricultural College, Western Australia, from 23 to 27 August 1976.

Muresk is actively involved in research programmes associated with selection of desirable traits in sheep, manipulation of ovulation rates, synchronization of oestrus and long-term storage of ram semen.

The main themes of the congress will be selection for production, control of reproduction and artificial breeding.

Those wishing to attend, or present papers, films or demonstrations, or receive further details, should write to:

The Chairman,
International Sheep Breeding Congress,
Muresk, Western Australia 6401,
Australia

Subscription rates

We regret that increases in printing, paper and postage costs since 1972 have made it necessary to raise the subscription rates for *World Animal Review*, starting with the first issue for 1976, No. 17. The new rates* are:

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Till the end of 1975, current subscriptions may be renewed at the old rate (Lit.1 950 per year) for one or two years.

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Third International Karakul Symposium

The Third International Karakul Symposium on karakul sheep breeding was held in Samarkand, U.S.S.R., from 22 through 27 September 1975. The symposium dealt with the following topics: the state of the world karakul industry; genetics of karakul sheep selection; breed, ecological and farm types of karakul sheep; effects of feeding and feed additives on karakul pelt quality; development of cultivated pastures and hay production in karakul sheep raising areas; methods and mechanical techniques of pelt processing and dressing; manufacture of karakul articles; and the international karakul market.

Information on the proceedings may be obtained from: P.I. Morozov, Chairman of the Organizing Committee, Room 204/2, 1/11 Orlikov per., Moscow 107139, U.S.S.R.

PAG Compendium

Between 1956 and the end of 1973 the Protein-Calorie Advisory Group of the United Nations system (PAG) issued about 600 documents which are not generally available in depositary libraries. These have now been gathered into a series of nine volumes, totalling more than 7 000 pages and grouped into the following 12 sections: Food Science and Technology — General; Food Science and Technology — Specific; Agricultural Produciton; Food Toxins; Testing of Foods; Applied Nutrition; Nutritional Science; Food and Nutrition Policies and Planning; Marketing and Distribution; Systems Analysis; Documentation; Country Reports. Prefaces and indexes have been added. Two copies of this compendium are available in FAO Headquarters (one in the general library and one in the nutrition library). The price is US$650.00.

United States orders should be sent to: Halsted Press, Division of John Wiley & Sons, Inc., 605 Third Avenue, New York, N.Y. 10016.

All other countries should send orders to: Worldmark International Documentation, Halsted Press, Division of John Wiley & Sons, 242 East 50th Street, New York, N.Y. 10022.

Dairy research

The annual report for 1974 of the Hannah Research Institute, Ayr, Scotland, gives details of research work done during the year in the four main departments on the production and utilization of milk. The principal areas of research covered are:

herbage production, conservation and utilization by the dairy cow, milk composition and milk secretion, nutritive value of milk protein, milk analysis, hygiene of milk production, processing characteristics of milk and milk powder, and environmental physiology and energy conversion with particular reference to thermoregulation, metabolic responses to cold, and biology of the skin of cattle.

Further information may be obtained from Professor J.A.F. Rook, Director, The Hannah Research Institute, Ayr, KA6 5HL, U.K.

Fourth international course on dairy cattle husbandry

The fourth of the series of international courses on dairy cattle husbandry will be held in the Netherlands from 15 March to 18 June 1976. Participants should have had university-level training in agriculture or veterinary science and three years' experience in dairy cattle husbandry or a closely related subject. The course will be conducted in English. Further information may be obtained from the Director, International Agricultural Centre, P.O. Box 88, Wageningen, Netherlands.

Indian dairy products

K.S. RANGAPPA and K.T. ACHAYA. Asia Publishing House, New Delhi, London, New York, 1974. 386 pages. Price: Rs.40. (In English)

The book is a revised and expanded second edition of *The chemistry and manufacture of Indian dairy products*, published by the same authors in 1948. It deals with milk production from buffaloes and cows, and with milk products in India, describing rural and nonmechanized dairy practices in common usage, as well as relating them, where possible, to a modern technological approach.

The book is in three parts. The first, entitled: "Milk and unfermented milk products" (115 pages), is concerned with Indian milch animals, milk production and yields, composition and properties of milk, milk consumption, economics of cow and buffalo (including measures for improvement), adulteration and legal standards, bacteriology and heat treatment, and various national unfermented products. The second part (30 pages) deals with traditional fermented milk products (including butter), their composition and nutritive value, manufacture and quality, and scope for development. The third part (216 pages) is devoted entirely to ghee: its place in the diet, attributes, preparation and grading of ghee, composition and constituents of ghee, its analytical characteristics, the adulteration of ghee and its detection, and rancidity in ghee.

Reference is frequently made to research results and to milk production and dairy products in other parts of the world. The bibliography is comprehensive, both in the number of publications and in the time span covered (about 70 years), and it shows also the considerable range of research in dairying in India.

It is unfortunate that the statistics illustrating livestock population and milk production are quoted from sources published not later than 1960. Nevertheless, most of the conclusions drawn from the figures may still be valid, at least in principle. The latest publication quoted in the section on ghee is dated 1969.

The volume is primarily intended as a textbook for students of dairying in India. But its rather advanced scientific approach may limit its use for training purposes. However, it compiles useful information on buffaloes, which may help promote the development of this hitherto neglected animal as an important milk producer in countries where the introduction and management of high-yielding dairy cattle has proved to be difficult and uneconomical. As ghee is an important milk product in many developing countries, the third part of the book can be of particular benefit for development of ghee production and marketing, even outside of India.

Indian dairy products provides interesting reading for people involved with dairying and milk technology/chemistry in all parts of the world.

L.S.

Animal reproduction and artificial insemination

Riproduzione animale e fecondazione artificiale. T. BONADONNA. Unione Tipografico-Editrice Torinese, Corso Raffaello 28, 10125 Torino, Italy, 1974. 621 pages, numerous figures, tables and references. Price: Lit. 18 500. (In Italian)

This book is divided into 23 chapters covering semen collection, processing and insemination techniques in domestic animals, and methods of evaluating semen and assessing its fertilizing capacity. There is also a chapter on the pathology of semen and spermatozoa. The book is generously illustrated.

This publication provides a comprehensive account of the development of artificial insemination throughout the world, a development in which the author, Professor Telesforo Bonadonna, is a prominent and well-known pioneer.

C.A.H.

Basic animal nutrition and feeding

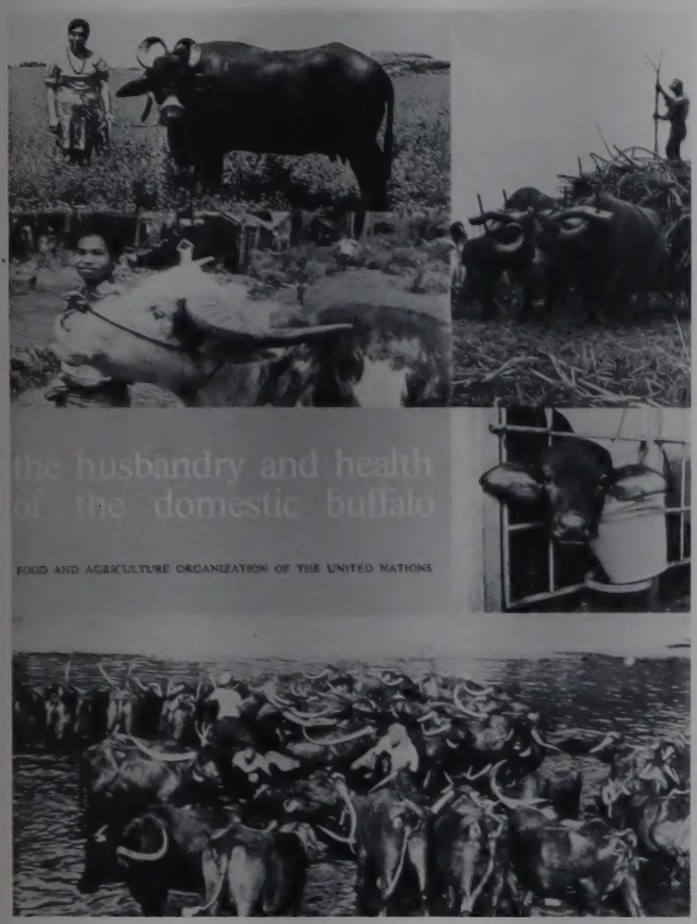
D.C. CHURCH and W.G. POND. Albany Printing Co., Albany, Oregon, U.S., 1974. First printing, 300 pages, numerous tables, figures and references. Price: soft cover $12.60; plastic cover $13.60. (In English)

This book is intended for readers with a knowledge of general chemistry and preferably some exposure to organic and biochemistry. Some understanding of animal biology and husbandry is also necessary. The book is divided into three parts. The first part includes a comparative account of the gastrointestinal tract of monogastric animals, ruminants and birds, as well as a description of techniques used for the measurement of nutrient utilization. The second part deals with the nutrients required by farm animals and provides basic information on carbohydrates, proteins, lipids, macro and micro elements, vitamins and their metabolic functions. One chapter of this part is devoted to non-nutritive feed additives and growth stimulants, including steroid hormones. The third part is concerned with applied animal nutrition problems: it discusses nutritional needs in relation to productive functions, factors affecting feed consumption, feed preparation and processing and ration formulation.

Feedstuffs used in animal feeding are described and include consideration of the importance of utilizing by-products and wastes from animals and plants.

Tables of feed consumption and NRC tables on nutrient requirements are presented as appendixes. References to literature are provided at the end of each of the 20 chapters comprising the book. This publication will serve to guide the student of animal nutrition through the important basic and applied areas of the subject.

K.S.



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